Instruments

THE MAGAZINE OF

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Vol. 16
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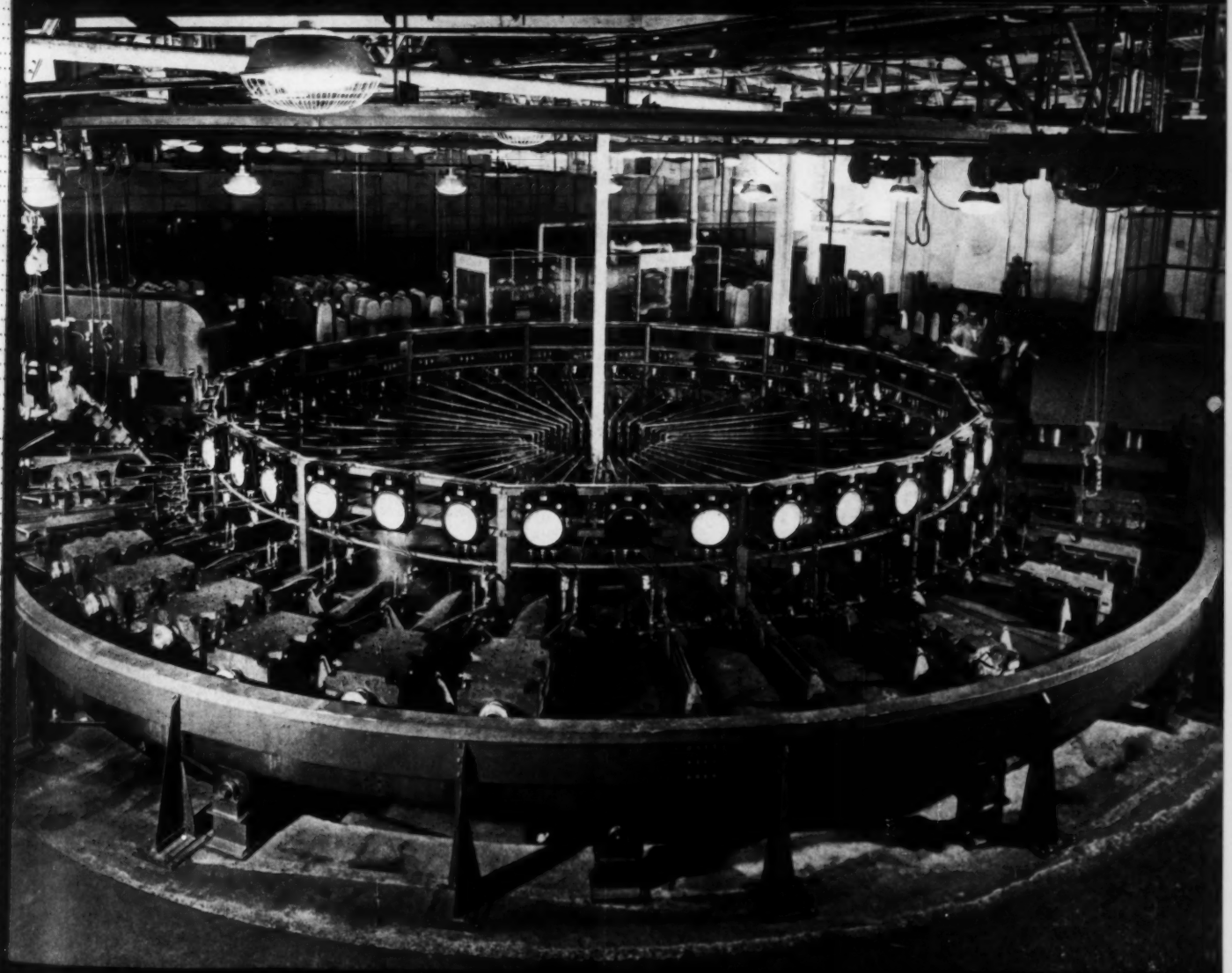
1943
No. 12



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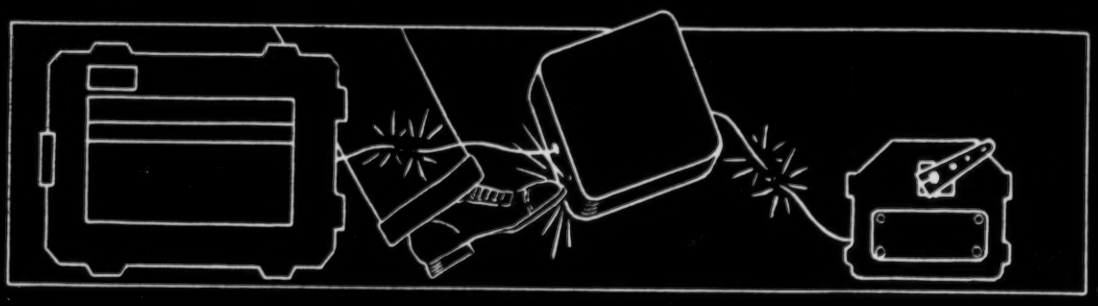

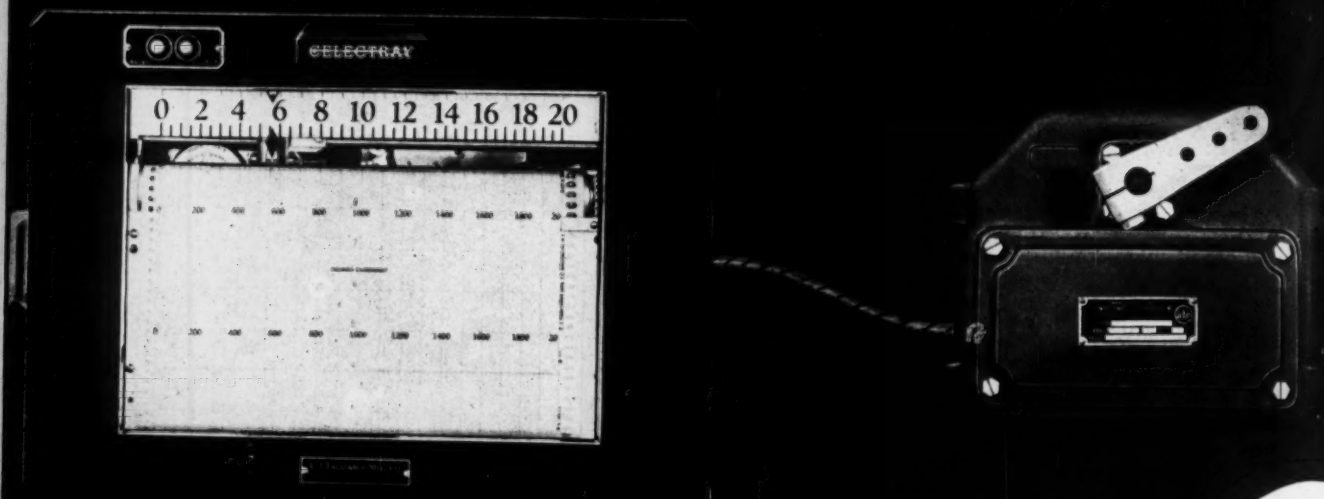

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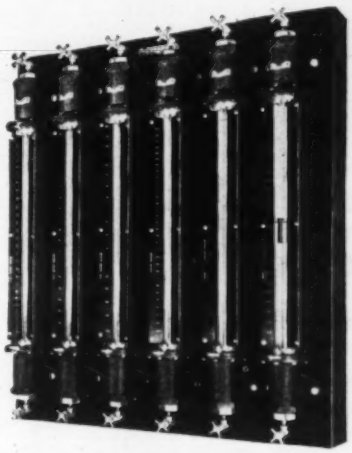

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(*Right*) This armored Stabl-Vis rotameter is used for ground tests on high pressure hydraulic oil systems and accessories. Manufactured in a series of designs for pressures from 600 to 10,000 pounds. The only flow rate meter that will handle viscous flows with high accuracy. Write for bulletin 43-D.

WEIGHT RATE TEST ROTAMETER

(*Left*) The Figure 12 Weight Rate Test rotameter combines the full features of the Stabl-Vis rotameter and measures liquid fuels directly in pounds per hour with its high accuracy unchanged by wide variations in viscosity and density in the fluid being metered. It is used by practically every manufacturer of aircraft equipment for measuring flow rates of liquids and gases.

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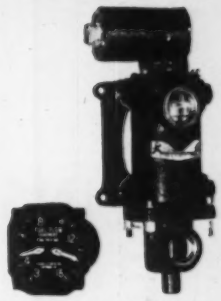

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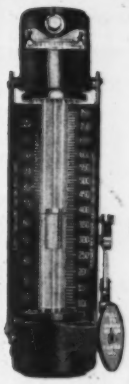

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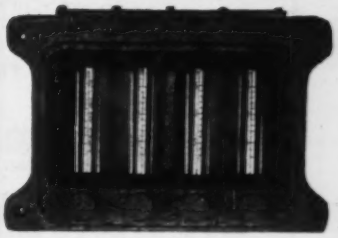

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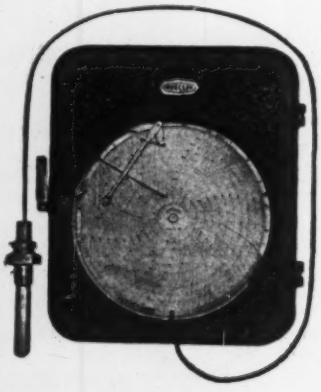

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Not Afterthoughts but Essentials

ONCE more, a war plant built in record time could not start operations because the instruments were not installed—and, as usual, the Armed Forces officers associated with the project were nearly frantic. I don't know the details because I was in New York when the urgent phone call came, but some kind of vitally important process could not be started for want of several potentiometer type or self-balancing bridge recorder-controllers. These are high forms of modern industrial process control instruments: deliveries take months. So here's another war process that's being started by connecting up a number of second-hand portables and having three shifts of men and girls operate them twenty-four hours a day until the automatic controllers are installed. It's enough to make the angels weep!

And yet, it's impossible to "point the accusing finger" at any group. The MAJORITY of consulting engineers, process designers, Army and Navy technical officers in charge, civilian industrial chemists, etc., KNOW that instruments are essential. As a rule, war plants are not only designed and built in record time but start operations without delays—thereby bearing witness to the perfect teamwork of all concerned—proving that instruments had not been forgotten.

It's only a minority of such design-and-construction teams that fail to think of instruments. The members of these few teams probably don't subscribe to *Instruments*, so there's no use in my preaching a red-hot sermon. Calmly and mildly—but earnestly—I urge every subscriber to do missionary work. Bear in mind and propagate the slogan that INSTRUMENTS ARE NOT AFTERTHOUGHTS BUT ESSENTIALS. —MFB

Hail to the ASME!

IT has been our custom, since the Tenth Anniversary issue of January 1938, to make every January issue a special one, devoted to a single timely theme. We believe that all six of these annual issues aided American Technology and that those of 1940 and 1941 aided the National Defense Effort. Certainly, those of 1942 and 1943 aided the War Effort and won thousands of new subscribers in war industries and in the Armed Forces. Therefore, in view of WPB paper tonnage limitations, we decided last summer against a special issue in January 1944: we did not want word-of-mouth fame to stimulate demands that could not be met. This did not mean "holding out" anything of value: on the contrary, we intensified our efforts to serve a useful diet of timely subjects. It meant that the January issue would be a balanced meal like every "ordinary" issue.

It is an editor's duty to know not only the tastes but the habits of his readers. I've discovered that YOU have become accustomed to a special January issue of *Instruments*, to the extent that you would miss it.

It so happens that I joined the American Society of Mechanical Engineers shortly after my return from the first AEF twenty-four years ago. I soon became active in it. In 1924 I was Secretary of its National Defense Division and began my efforts to have it recognize Instrumentation.

Well, this is a war year and the ASME has recently given Instrumentation the highest form of recognition by creating a Professional Division on Industrial Instruments and Regulators. To me, 1944 will be an important twentieth anniversary. Can you blame me for playing a hunch? I saw a "natural" for an Annual Issue this coming January: a special issue in honor of the ASME. Naturally, I liked my own idea, but the question was, how would YOU like it? Specifically, could such a plan make it possible to serve you a balanced meal which, although primarily "mechanical," would nevertheless contain lots of vitamins and other nutritive elements desired by thousands of subscribers in chemical, electrical, electronic, biological and numerous other "non mechanical" fields?

The answer came in the form of the program for the Annual Meeting of the ASME (Nov. 29-Dec. 4), printed in the November issue of *Mechanical Engineering*. This program shouted an emphatic YES. I've just returned from this important gathering, convinced that it no longer is proper to speak of the mechanical engineering "field"—there are hundreds of these fields and they overlap nearly all other fields of science and technology. Mechanical engineering, in this glorious America of ours, and in this year 1943, is much like Instrumentation itself: a "horizontal" rather than a "vertical" sphere of activity.

Outgoing President Harold V. Coes, in whose administration the II&R Division was established, graciously gave me the green light, and Division Chairman Everett S. ("Sam") Lee, Editor G. A. Stetson, Acting Secretary Ernie Hartford, and others concerned, promised to handle details.

What will the January issue be like? It depends on them. You see, as I told President Coes and Editor Stetson, the latter will be the Guest Editor, the ASME will boss the job and I shall be the assistant cook. The exact diet will depend also on the original authors. There were more than a hundred presentations and discussions, with as many as eight or ten simultaneous sessions and committee meetings going on. Some papers had not been whipped up into final shape, the authors using lantern slides and speaking from rough notes. Fortunately, some of the measurement and control papers had been completed and even pre-printed.

In the January issue there will be at least abstracts of nearly all ASME papers of interest to *Instruments* subscribers, and also "extended abstracts" with essential diagrams, of several papers to be selected by my ASME bosses. (Don't tell anybody, but I've recommended the dishes YOU prefer!) If possible, there will also be the substance and in some cases the entire text, of six industrial instrument papers which were "oral presentations" not for publication in *Mechanical Engineering* or in the *Transactions* of the ASME. —MFB

The Counter Reads 00192

and thereby registers the end of the sixteenth year of *Instruments'* service to users of measurement and control devices—service to the

UNITED STATES OF AMERICA

The entire staff of *Instruments* wishes you

A Merry Christmas and a Happy New Year

Viscous Fluid Flow through a Small (0.03″) Orifice in the Reynolds Range from 0 to 2000

By WILLIAM JONES
Chemical Engineer
and OTTO LUTHERER
Chief Engineer
The North American Manufacturing Co.
Cleveland, Ohio

CONTROL of fuel-air ratio in industrial furnaces is becoming more exacting by reason of the necessity of maintaining definite furnace atmospheres throughout the ranges of the burners used. In order to accomplish this, it is necessary to control the fuel and air flow so as to maintain a constant ratio regardless of the quantity of fuel being burned. Information is available concerning the flow of air through valves but there is not much data [outside of the noteworthy work of Tuve and Sprenkle*] concerning the flow of liquids such as fuel oil through valves or fixed orifices. The following discussion and data resulted from tests made with fuel oil to determine the characteristics of viscous liquid flow through an orifice.

The weight rate of flow of a fluid through an orifice is determined by the relation—

$$W = CA\rho\sqrt{(2gh)} \quad . \ . \ . \quad (1)$$

where W = flow in lbs./sec.
C = coefficient of discharge
ρ = density of fluid in lbs./ft.^{3}
g = acceleration due to gravity in ft./sec.^{2}
h = pressure drop across the orifice in feet of fluid.

The C value of an orifice will depend upon: (a) its dimensional characteristics, (b) its shape, (c) the relation between the orifice area and the area of the pipe or chamber feeding the orifice, (d) the Reynolds Number N_R. The following data and discussion are concerned with the C value of an orifice with N_R values between 0 and 2000 at the orifice.

Reynolds Number is a dimensionless quantity that relates weight rate of flow of a fluid with viscosity and size of orifice as follows—

$$N_R = \frac{Du\rho}{\mu} = \frac{4W}{\pi\mu D} \quad . \ . \ . \quad (2)$$

where D = orifice diameter in ft.
u = fluid velocity through the orifice in ft./sec.
μ = viscosity of the fluid in lbs./ft. sec.
ρ = density of the fluid in lbs./ft.^{3}
W = flow in lbs./sec.

For any one orifice diameter the same N_R value can be obtained with different

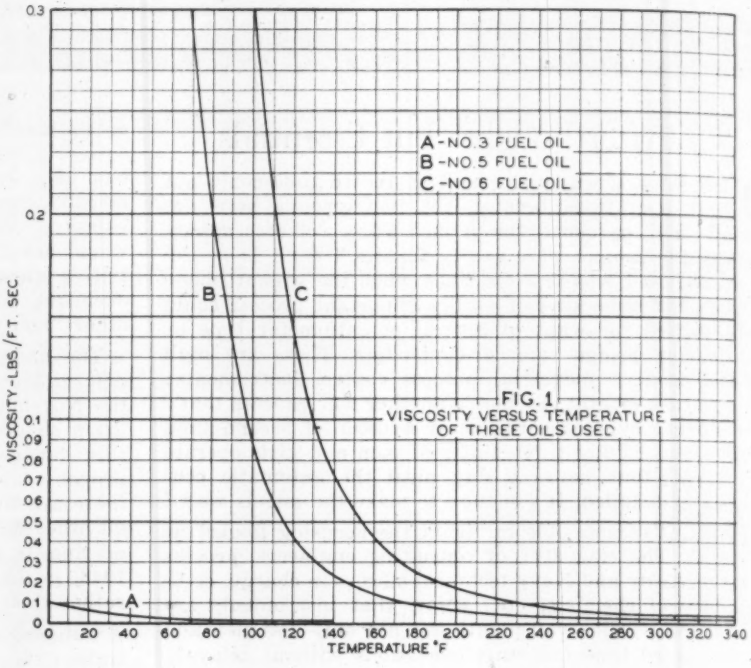


FIG. 1 VISCOSITY VERSUS TEMPERATURE OF THREE OILS USED

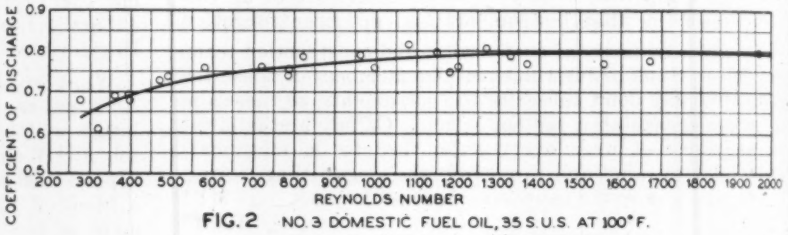


FIG. 2 NO. 3 DOMESTIC FUEL OIL, 35 S.U.S. AT 100° F.

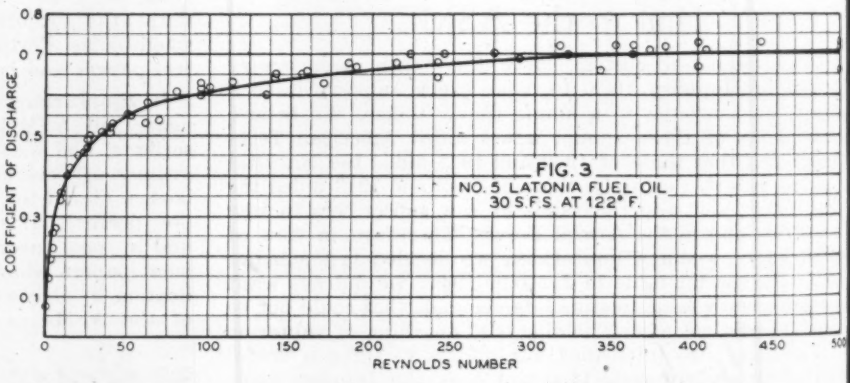


FIG. 3 NO. 5 LATONIA FUEL OIL 30 S.F.S. AT 122° F.

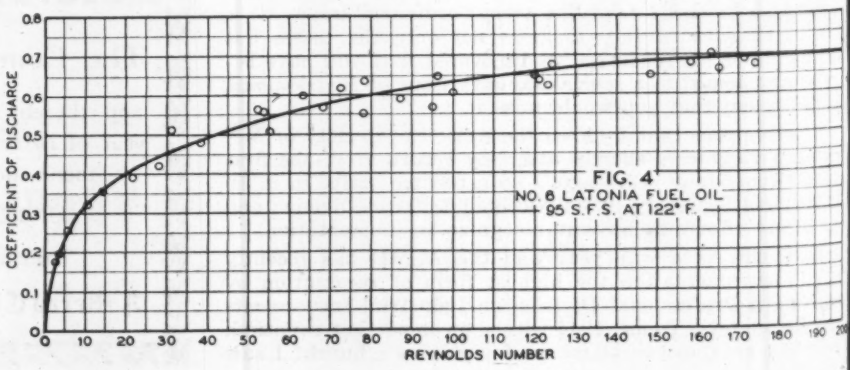


FIG. 4 NO. 6 LATONIA FUEL OIL 95 S.F.S. AT 122° F.

W values by changing the μ value, for example, if the weight rate of flow is doubled, the N_R value can be held constant by doubling the viscosity.

By measuring the weight rate of flow and pressure drop through a known orifice with a fluid whose viscosity and density are known, both the N_R value and the C value can be calculated, and by varying the viscosity and weight rate of flow a curve is obtained showing the variation of C versus N_R.

The weight rate of flow is varied by varying the pressure drop across the orifice and the viscosity is varied by varying the temperature of the fluid.

The orifice used in this investigation was circular, with a diameter of 0.030" and a length of 1/32". The fluids used were—

(1) No. 3 Domestic Fuel Oil
(2) No. 5 Latonia Fuel Oil
(3) No. 6 Latonia Fuel Oil

Fig. 1 shows the temperature versus viscosity curves of these three fluids.

The results obtained are shown in Figs. 2, 3, 4, 5 and 6. Figs. 2, 3 and 4 show the results of the individual fluids, and Figs. 5 and 6 represent the final analysis of the individual curves. Fig. 6 is identical with Fig. 5 but is plotted on semi-log units.

The conclusion to be drawn from these results is that the coefficient of discharge of an orifice is a function of log N_R when N_R lies between 0 and 2000.

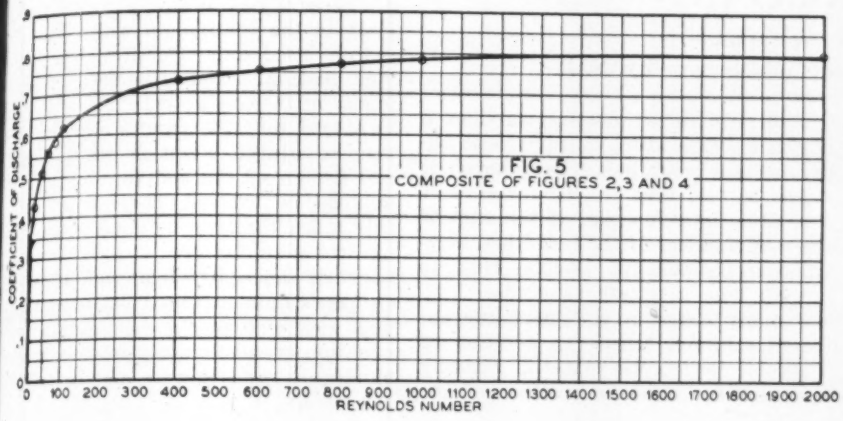


FIG. 5
COMPOSITE OF FIGURES 2, 3 AND 4

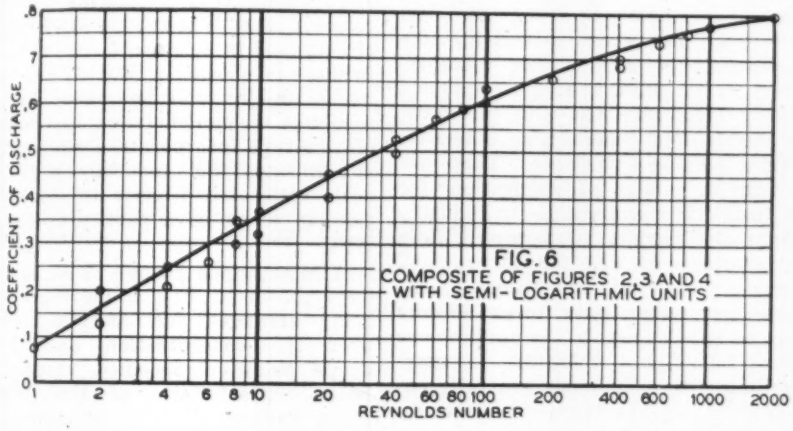


FIG. 6
COMPOSITE OF FIGURES 2, 3 AND 4
WITH SEMI-LOGARITHMIC UNITS

*"Orifice Discharge Coefficients for Viscous Liquids" by G. L. Tuve and R. E. Sprenkle, *Instruments*, Vol. 6, Nov. 1935, pages 201-206.

DISCUSSIONS by Ed. S. Smith, W. H. Carson & H. J. Evans, Ronald B. Smith, C. E. Lucke, and Edgar Buckingham, *Instruments*, Vol. 8, Aug. 1935, pages 202-205, 225.

AUTHORS' CLOSURE, *Instruments*, Vol. 8, Sept. 1935, pages 232-234.

DISCUSSIONS

By M. F. BEHAR, Editor *Instruments*

Grateful congratulations are due to the authors for investigating this heretofore-neglected field. The suggestion was made to the authors that their important report deserves discussion; they welcomed it; here is a "starter":

1. Though referred to as an "orifice," the constriction (0.03" diam. × 0.03125" long) does not meet the requirements of a metering orifice: the length, also known as the thickness ζ (zeta), must not exceed ⅛ of the orifice diameter or ¼ of the dam height. (See article by Beitler in Jan. 1934 *Instruments*, pages 3-6,8, also latest ASME Fluid Meter Report.) Fig. 7 of this discussion pictures these shape factor requirements. If these are not met, the curves are not comparable with those of metering orifices. The authors might do well to report upstream and downstream diameters, sharpness of edges, etc., and give correlation factors for applying their findings to commercial meters installed by fuel-oil users.

2. It is possible that the curves of Figs. 5 and 6 are smoothed out too much. Having been privileged to examine the original test sheets from which Figs. 2, 3 and 4 were drawn, the writer has carefully drawn Fig. 8, which he believes to support the view that every type of fuel oil has a meter-calibration curve of its own.

3. If Fig. 8 is a faithful presentation of the actually-obtained test data (and care was taken to make it so), then only the Fig. 2 points were "self-consistent" and disturbing factors appear to have affected the tests with Latonia fuel oils. The writer appreciates, of course, that the experimental difficulties must have been extraordinary.

Other discussions are invited. They will be printed in an early issue, with the Authors' Closure.

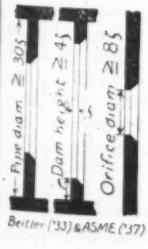


Fig. 7

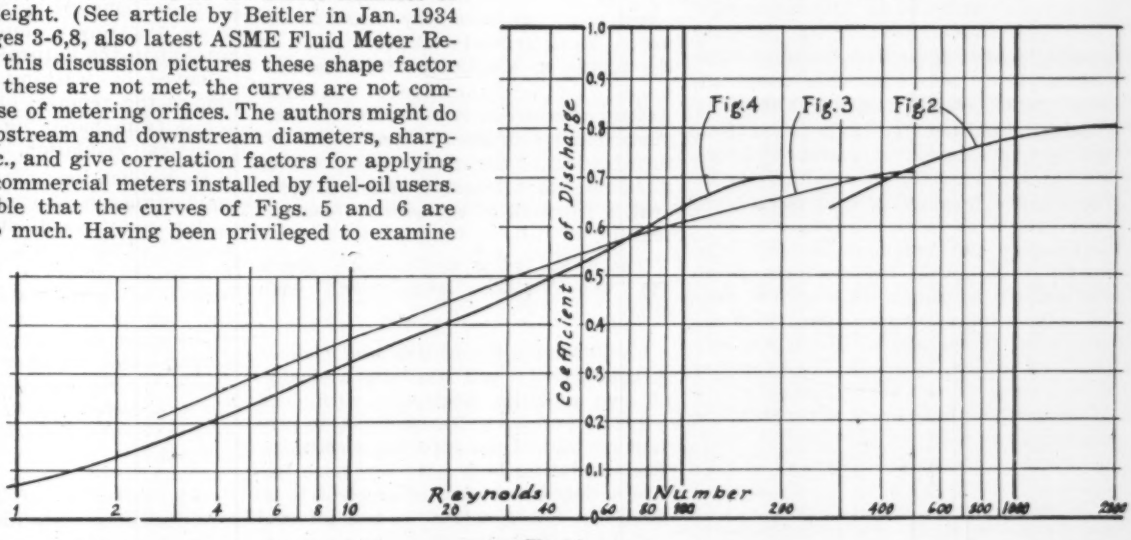


Fig. 8

Electrolytic Conductance Measurements in Industry*

By NATHAN SCHNOLL

President, Industrial Instruments Inc., Jersey City, N. J.

PRESENT-DAY technique in measurement of electrolytic conductivity dates back over fifty years to Kohlrausch.[1] While conductivity measurements have been firmly established for many years in the chemical laboratory, really widespread application in industry has begun only recently. Undoubtedly, one of the reasons for this has been the comparative complexity and high cost of the apparatus commercially avaliable for this purpose.

Electrolytic conductance differs fundamentally from conductance in metallic wires in that the passage of the current in the former case is accompanied by material effects within the electrolyte, whereas, in metallic conductors, there is no change in the physical condition of the conductor during or after the passage of the current. This fundamental difference indicates that the basic mechanism of the conductance may not be the same in both cases. The passage of the electric current through the metallic conductor is due to a direct transfer of electrons, whereas in the electrolyte the passage of the current is by means of ions. The ions involved in the passage of current through an electrolyte depend upon the nature of the electrolytic material in solution.

While the fundamental laws underlying the conduction process in electrolytes appear quite simple, it must be admitted that the theoretical explanations advanced so far do not account for all of the observed phenomena. The basic principles hold true only for dilute electrolytes. There is scarcely a single statement which can be made as to the conductance process in electrolytes which holds true without exception. The conductance is, in general, proportional to the concentration of the electrolyte in solution. This does not hold true when the concentration reaches a sufficiently high value. For example, a solution of sodium hydroxide reaches a maximum conductivity in the neighborhood of 20% at room temperature. With further increase in concentration, the conductance falls. It might be said that the conductance of electrolytic solutions of a given concentration increases in general with increase in temperature. There are exceptions to this, however. For example, it was early shown that some solutions of copper sulphate show a decrease in conductance with an increase in temperature in the neighborhood of 128°C. In fact, almost all electrolytes show a negative temperature characteristic under certain conditions.[2] In general, it might be said that the conductance of a solution is a function of the sum of the conductances of the individual electrolytic components. While this is largely true in dilute solutions, there are many cases in the more concentrated solutions where an addition of a second electrolytic material actually decreases the total conductance of the electrolyte.

These examples, however, need not discourage one from attempting the application of conductance measurements in the plant. They are mentioned merely to indicate that some care must be exercised in generalizing, otherwise trouble may be experienced. There are an infinite number of applications for conductivity measurements in industry where the simple, fundamental laws hold sufficiently well for all practical purposes so that conclusions based upon the conductivity measurements may be relied upon. In the applications which follow, and which are necessarily limited to some more generally encountered in practice, conductivity measurements of moderate precision are being found an extremely valuable adjunct to the measuring and control methods normally employed.

Before going into the industrial applications of conductivity measurements, it might be well to point out the essential differences between electrical measurements of pH and conductivity. Because both methods are electrical, because both are often applied to similar control problems and because of superficial similarities in the appearance of the apparatus used, they are sometimes confused by instrument users. Measurements of pH (which is the acidity or alkalinity of a solution) involve the determination of potential difference between two electrodes. Conductance measurements involve the determination of the ohmic resistance of a column of electrolyte and, in general, a function of the solution concentration.

There are some applications where the two methods supplement each other.

Conductivity Apparatus and Cells—A conductivity cell consists, basically, of two metallic electrodes with lead wires and an insulator assembly to prevent contact of the opposing electrodes. The insulating body also serves to isolate a definite column of electrolyte so that the cell constant is not affected unduly by the presence of tank walls or other adjacent bodies. The electrodes are generally of platinum or of a metal inert in the solution in which the cell is to be used, and covered with a platinum coating. Despite the seeming simplicity of the conductivity cell, it should be stated that the results obtained depend to a large extent on proper choice and design of the cell for the specific application involved. There is undoubtedly much that can be done by the apparatus manufacturer to provide a cell which is inherently foolproof. It is the speaker's opinion that most of the difficulty experienced in the practical application of conductivity measurements resides in, or could be eliminated by cell design.

The measuring apparatus generally consists of a Wheatstone Bridge. The circuit used in a compact self-contained bridge[3] is shown in Fig. 1. In this bridge an electron-tube indicator serves to detect the null balance. Instruments of this type incorporate a temperature compensator and generally provide a scale calibrated directly in concentration, in terms of a particular electrolyte.

A Wheatstone Bridge of similar design shown in Fig. 2 incorporates a relay arranged for operation whenever the concentration exceeds or drops below a specified value. The basic characteristic of the Wheatstone Bridge, whereby measured values are independent of line voltage variation or tube characteristics, is retained in the control type of instrument shown in Fig. 2.

Applications

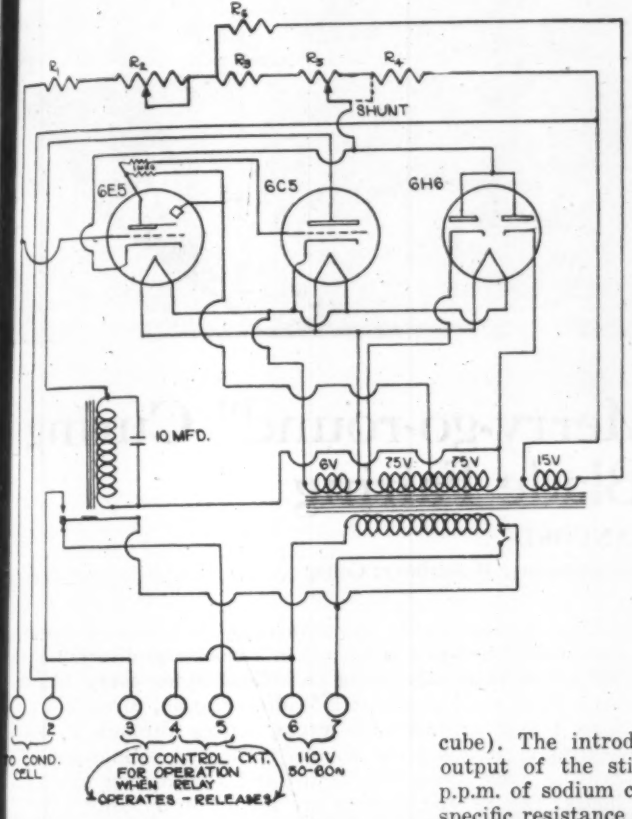
Rinsing—There are many industrial processes where a material is treated with an acid or salt solution, and where it is important to remove the treating solution to avoid difficulties later on. For example, wool is treated with a caustic solution which subsequently must be removed by washing. In other cases, electrolytic impurities originally present in the natural product must be removed by washing. An example of this is the removal of electrolytic material from paper intended for use as electrical insulation.

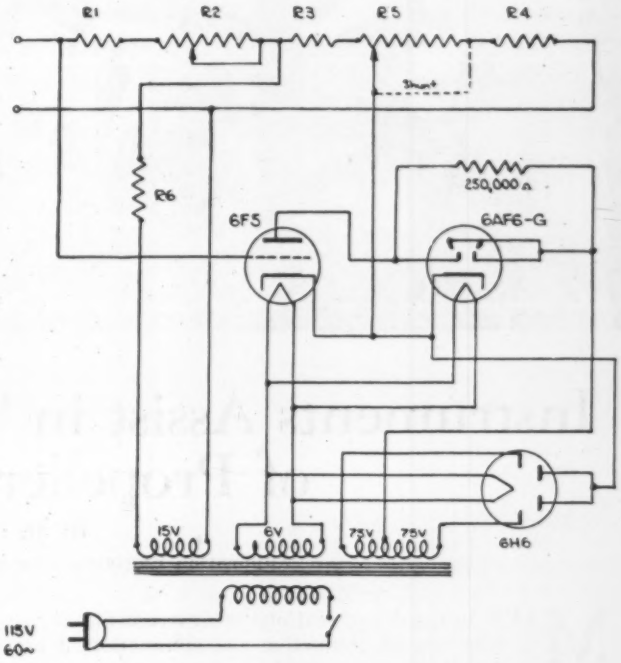
In applications of this character, a conductance measurement on the rinse water is an excellent measure of the amount of electrolytic material remaining in the material being rinsed. By means of conductance measurements the rinsing process may be followed from start to finish, it being possible to determine whether the washing has proceeded far enough, or whether it is being carried needlessly beyond the point where satisfactory results can be obtained.

Concentration of Electrolytes—The problem of maintaining the concentration of a solution is a widespread one.

*Talk before the Society for Measurement and Control (New Jersey), Newark, N. J., May 4, 1943.

For example, in the washing of bottles in beverage plants throughout the country, it is common practice to use a 2% to 3% caustic solution. It is important to maintain the concentration of the soaker tank at a definite value. If the concentration is too low, the requirements for clean and sterile bottles will not be met. If the concentration is too high there is an unnecessary waste of material and etching of the glass





may be encountered. Conductivity measurements have been successful in this application, it being found possible not only to control the concentration to a sufficiently high degree of precision, but the measurements can be made on the solution in the tanks as the bottles pass through the washing machine without the necessity for withdrawing samples.

Another application of similar nature is that of maintaining the concentration of ammonium borate solutions as used in the manufacture of electrolytic capacitors. In this case a series of solutions, varying in concentration from 0.12% to 0.29%, are maintained at the proper concentration by conductance measurements.

Distilled Water and Steam Condensate—One of the earliest commercial applications for conductivity measurements with which the speaker is familiar is that of the detection and estimation of impurities dissolved in water.[4] Ordinary faucet water contains in solution a sufficient quantity of salts and other substances to be a fair conductor of electricity. Pure distilled water, however, is a comparatively poor conductor, the value of the specific conductance of the water being an excellent measure of its purity. For judging the quality of distilled water or steam condensate, a conductivity measurement is both simple and satisfactory.

Water obtained from a good commercial still in proper operation has a conductance of approximately 2 micromhos (500,000 ohms per centimeter cube). The introduction in the water output of the still of as little as 1 p.p.m. of sodium chloride will drop the specific resistance of the water down to less than 300,000 ohms.

The steam condensate in a well maintained power plant system is nearly the equivalent of distilled water. The slightest priming of the boiler may be detected by conductance measurements on the steam condensate.

There are many cases where steam is used in process in the plant to heat acid or salt baths of such a nature that leakage into the steam condensate might cause serious damage, particularly if the steam condensate is being returned to the boiler. Conductance measurements have been found extremely useful to determine when such leakage takes place. Control apparatus arranged so as to ring an alarm when the conductance of the steam condensate exceeds a given value is particularly valuable.

Boiler Water Concentration — A knowledge of the total solids in boiler water as well as in the feed water is considered essential in most power plants. While chemical methods (especially simplified for use by the boiler room personnel) are in wide use for this purpose, conductivity measurements have recently been applied widely. While conductance methods do not yield an analysis, they do enable one to obtain a good estimate of the total electrolytic material present. In a given locality, where the ratios of the various constituents present in the boiler water remain constant, conductance measurements have been found sufficiently accurate to entirely displace chemical methods. In this particular application, as well as many of the others discussed, the simplicity and ease of operation of conductivity equipment has been one of the determining factors in selecting conductivity apparatus rather than other methods. This is particularly true where routine measurements are in the hands of technically unskilled personnel.

Miscellaneous Applications—Conductivity measurements are being used successfully to check the timing of continuous pasteurizing machines.[5] In this particular application, raw milk is pumped through a chamber and brought up to a definite temperature. It is essential that the equipment be adjusted so that the milk is within the holding chamber for a definite period of time. In order to measure precisely the time of flow through the pasteurizing chamber, conductivity apparatus is used. A salt solution is injected into the liquid stream just before it enters the pasteurizing chamber. A conductivity cell right at the entrance to the pasteurizing chamber indicates when the more conductive stream of milk reaches that point. Another similar conductivity cell, located at the outlet from the pasteurizing chamber, indicates when the conductive body of the milk reaches the output. The difference in time between the indications of a

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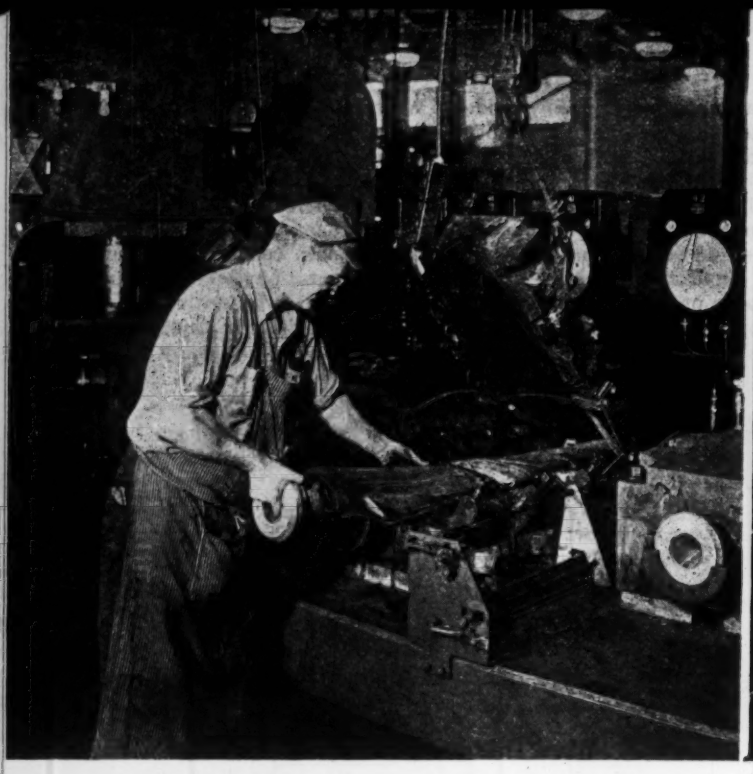

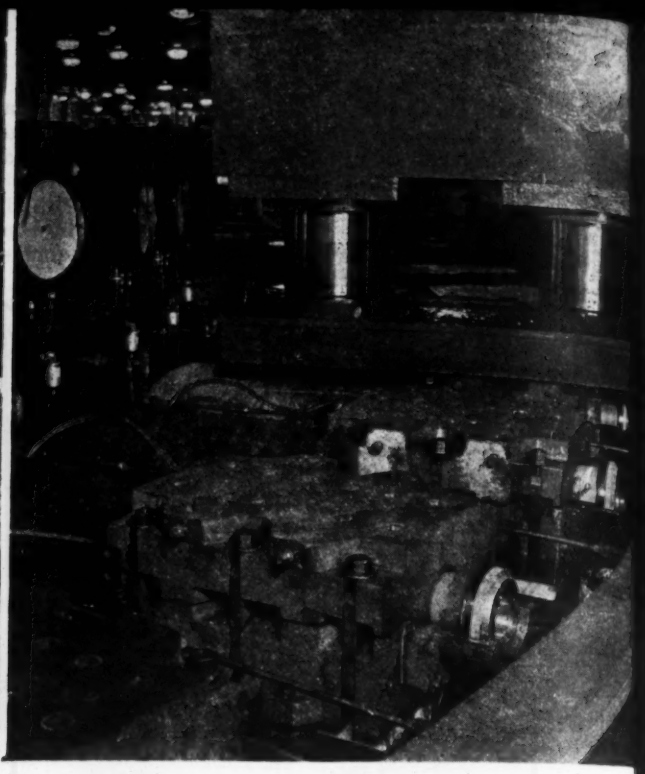

Instruments Assist in "Merry-go-round" Curing of Propeller Blade Fairing

By D. C. SANFORD

Application Engineer, The Bristol Company, Waterbury, Conn.

MANY unusual applications of instruments to assist in speed-up of production and elimination of bottle-necks on critical parts have been opened up by the exigencies of World War II. One of the more unusual machines of this nature was recently installed by the Hamilton Standard Propeller Division of the United Aircraft Corporation at East Hartford, Conn. This machine consists of a 100-ton rotary "merry-go-round" curing press for the curing of Ebonite fairings (cuffs) on propeller blades. Forty-two Bristol recorder-controllers play an essential part in the close control and uniform product obtained from this unique press. The machine is based on a turnable 40 feet in diameter mounted on rollers and revolving on a concrete foundation. [Complete view on front cover.—ED.] The outer rim of the table is flat and is divided into forty-two separate sections, each of which is a sector carrying a half-ton mold into which the blade fairing assembly is inserted for curing. Each section has its individual system of air, steam, water and electricity; and is automatically controlled by the Bristol recorder-controllers and cam-operated water and steam valves. Supply lines are brought in through the center of the turntable by swing joints and slip rings.

The forty-two Bristol Model 5040M Free-Vane air-operated recording pressure controllers revolve with the turntable and control the curing temperatures indirectly through control of steam pressure in the molds. Each instrument is of the throttling type and accurately controls the action of a ½" normally-closed diaphragm valve in the mold steam line. Permanent records of the curing times and pressures are obtained from 12" 24-hour charts on the instruments with a range of zero to 100 lbs./in.^{2}. The instrument control mechanisms consist of Bristol's Standard Free-Vane Air System in which a thin vane is floated between two jets of air. The back pressure of air caused by this system operates through a pilot valve to position the diaphragm steam valve to maintain a predetermined pressure in the curing molds.

The machine cures simultaneously two sets of twenty-one blades each and is turned in a clockwise direction by a 14" air cylinder advancing one blade sector every 12 minutes. Each mold starts at a loading station, turns to a gap type Farquhar hydraulic press, moves through a steam heating cycle and water cooling cycle, and is unloaded. The heating cycle takes 2½ hours and the cooling cycle 1½ hours. The 100-ton presses are set up on opposite sides of the turntable so that each blade is cured in one half revolution of the "merry-go-round."

At the start of the operation, the inside of the mold is coated with wax and the steam is turned on. A blade with the rubber fairing attached is then inserted into the mold, which is loosely bolted together. A turn of the table carries the mold under one of the hydraulic presses which closes under pressure. Excess rubber is forced out, the mold bolts are tightened, and the blade moves to the next position. A canvas and wool insulating blanket is thrown over the blade to protect its surface. The table then carries the mold through progressive steps to complete the heating cycle under controlled steam pressure. At this point, the steam valve is turned off by means of push rods operated by cams located in the outer periphery of the table. Refrigerated water valves are opened in a like manner and the molds are cooled until they reach the unloading station 180 degrees from the starting point.

The mountings of the rotary table are on steel springs, thus creating a slight "give" to bring the table into contact with the lower platen of the press while the mold is being closed. When the pressure is released the table lifts and clears the lower platen by about 1/16". Six Electro Lift worm drive hoists are mounted over the table to open and close molds.

The machine provides continuous uniform molding of the rubber fairing with a minimum of handling and has broken a former bottle-neck in this operation. Design and construction of this equipment was carried on by the L. Heres DeWyk Company of Ansonia, Conn.

Forces Involved in Curvilinear Motion

A "Refresher" for Instrument Men

By S. R. WILLIAMS

Professor of Physics, Amherst College, Amherst, Mass.

In demonstrating the first part of Newton's first law of motion, we saw that inertia is that property of matter which causes it to remain at rest when it is at rest, or to keep moving with uniform speed in a straight line, once it is set in motion, unless acted upon by an outside force.

If a body is moving in a straight path and is constrained to deviate from that course, then in a direction at right angles to that path, the speed or velocity of the body is changing from $v_0 = 0$ to some finite value $v_t = a_c t$. The body has an acceleration a_c which is always directed toward the center of the curved path and is equal to:

$$a_c = v^2/r = \omega^2 r = \frac{4\pi^2}{T^2} r = 4\pi^2 n^2 r.$$

Wherever an acceleration occurs for a mass m, there some force must be operating, such that $F = \frac{mv}{t} = ma$.

This force, like the acceleration, is directed toward the center of curvature; and this force which constrains a body

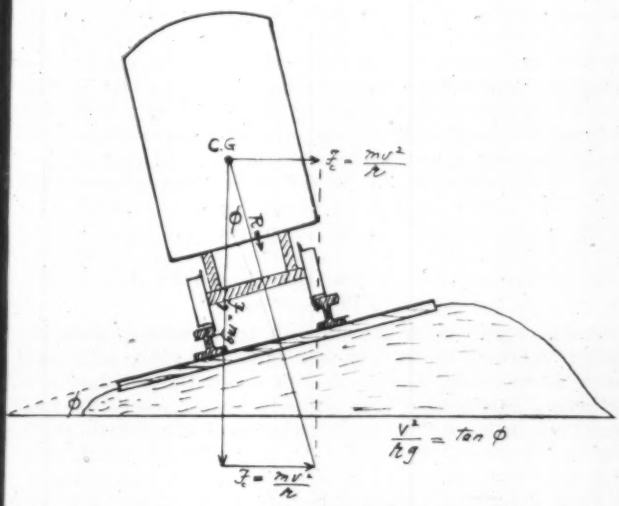

Fig. 1. On a railroad curve the roadbed must be "banked" so that for a given average speed the resultant force R acting on the car will be normal to the surface of the roadbed.

to move in a curved path we call the *centripetal* force. Expressed in terms of our defining equation of a force just given, we may write

Centripetal force =

$$F_c = \frac{mv^2}{r} = m\omega^2 r = \frac{4\pi^2}{T^2} mr = 4\pi^2 n^2 mr.$$

In the solution of various problems involving these central forces, we shall use whatever form of the equation we find most convenient for our purposes.

Why does the mud fly off from a rapidly moving automobile wheel in paths which are tangents to the surfaces of the wheels? Why do the sparks from an emery wheel perform in the same way? Simply, because it is the very nature of matter to move in straight lines and with uniform speed. If the mud had greater adhesive power, it would be pulled along with the tire on the wheel.

In solving problems concerned with curvilinear motion, it often is convenient to treat the reaction to being deflected from a straight path as a force equal but oppositely directed to the centripetal force and call it a centrifugal force. Thus a train in going around a curve tends to skid sideways because it wants to maintain a straight path.

This force is directed outward as shown in Fig. 1 where we wish to find the "banking" of the track, that is, the angle which the track makes with the horizontal. In laying out the roadbed, the engineer must determine what this angle is to be. He wants the surface of the roadbed to be at right angles to the resultant force acting on the train. The force of gravity mg acts vertically downward. Hence we lay off vectors to represent mg and the centrifugal force, mv^2/r.

Fig. 1 shows the geometrical figure which we employ. The resultant of $F_c = \frac{mv^2}{r}$, and $F_g = mg$ is indicated by the line R, where we get,

$$\frac{mv^2/r}{mg} = \tan\phi \quad \text{or} \quad \frac{v^2}{rg} = \tan\phi \quad \text{where } \phi \text{ is the angle}$$

between the surface of the road bed and the horizontal plane.

Demonstrations of Centripetal Forces

There are many demonstrations to show how bodies are constrained to move in curved paths and their tendencies to fly off on tangents.

When the balance wheel of a high-speed engine "bursts," it is not like an explosion. In an explosion the particles fly

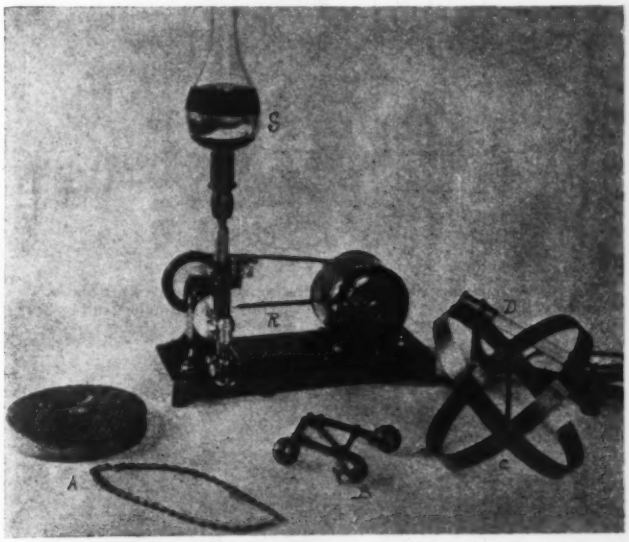

Fig. 2. (A) Chain ring on rotating disk. (B) Rotating governor. (C) Circular spring hoops which flatten on rotation. (D) Wooden ball rolls up inclined tube as it tries to keep going in a straight line. (R) Rotator. (S) Cream separator.

out radially from the center; but when a rotating body goes to pieces, each separate part flies off tangentally to the curved path in which it was rotating.

Demonstration of Why the Earth Is Flattened at the Poles

In Fig. 2(C) is shown a combination of two circular spring hoops at right angles to each other. When they are rotated about an axis in the intersection of the planes of the two hoops, those parts of the rotating hoops farthest from the axis have a greater tendency to keep on in a straight line than do those nearer the axis. As a result, this greater pull on the equatorial sections of the hoops as they rotate causes the hoops to flatten at the poles of rotation. The upper end of the axis is not rigidly attached to

the hoops, but is free to let the upper part of the hoops slide up and down on the axis and so flatten out as the hoops rotate.

Demonstration of the Principle on Which the Cream Separator Works

Fig. 2(S) shows a glass bowl which can be rotated. A mixture of mercury and water, blackened by ink, is put in the bowl, the quantity depending upon the size of the bowl. When this mixture is rotated with the bowl, the density of the mercury, being greater, and therefore mv^2/r being greater, the mercury presses out to the points farthest from the axis of rotation. This forms a ring of mercury on the equator of the bowl, and the blackened water distributes itself by the same law to points where the mercury has not displaced it.

The mercury is the skim milk and the water is the cream in the ordinary cream separator. All one needs to separate the two liquids are small tubes, one leading out from the mercury and the other from the water.

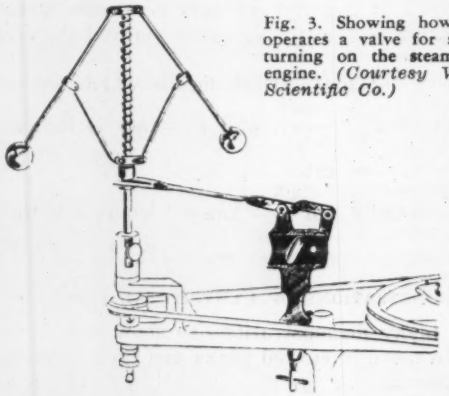

Fig. 3. Showing how the governor operates a valve for shutting off or turning on the steam for a steam engine. *(Courtesy W. M. Welch Scientific Co.)*

Demonstration of the Steam Engine Governor

(B) in Fig. 2 shows a model of a steam engine governor. When rotated, the arms stand out more nearly perpendicular to the axis the more rapidly the governor is rotated. To prevent excessive speed on a steam engine, the balls as they rise can be made to shut off the steam from the cylinders of the engine and thus reduce the speed. This action is indicated more clearly in Fig. 3 which shows a model of a nearly complete governor with the valve lever actuated by the sleeve. The same principle is utilized in centrifugal tachometers, except that the sleeve does not actuate a valve but actuates a pointer by means of a sector-and-pinion arrangement.

Demonstration to Show that Every Particle in a Rotating Body Tends to Get Away as Far as Possible from the Axis of Rotation

In Fig. 4, (F) is a brass ring about 8" in diameter. This is suspended by a heavy cord underneath the vertical axis of the rotator as shown in Fig. 5. As it begins to rotate with its plane in a vertical position, it gradually begins to pull up and spin with its plane in a horizontal position. In this position all of its parts are then revolving at the greatest distance possible from the axis of rotation. The position for spinning the ring and also the chain in the following demonstration is shown in Fig. 5. (E) in Figs. 4 and 5 is a chain loop which is suspended by a heavy cord as was the rigid ring in the previous experiment. When the chain ring is set in rotation it too will come up into a horizontal position and at the same time take on a circular form. (G) in Fig. 4 shows various wooden forms which rotate in ways we didn't suspect.

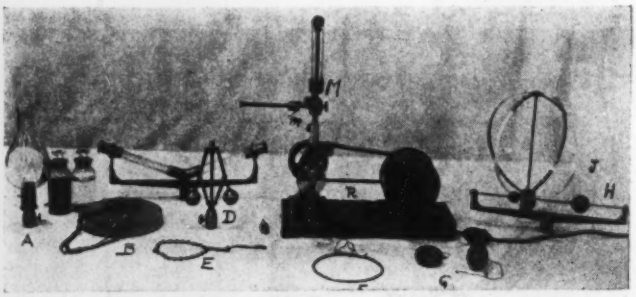

Fig. 4. Various gadgets for demonstrating the tendencies for bodies moving in curvilinear motion to keep on in a straight path.

Demonstration to Show how "Looping the Loop" Is Performed

In Fig. 6 is shown a metal-rail track with a small iron car on wheels. When this car with its rider is released from the position A, it will run down the inclined track gathering speed until it reaches the point where the track is curved in a loop. All along the track the inertia of the car tends to keep the car in a straight path. On reaching the loop this tendency to go in a straight path causes the car to press against the track with a force, $F_c = mv^2/r$ greater than the force of gravity $F_g = mg$, and so the car stays up against the track all the way around the loop and finally arrives at the farther end of the track where it is caught by the spring catch at B.

Why does the bareback rider lean in toward the center of

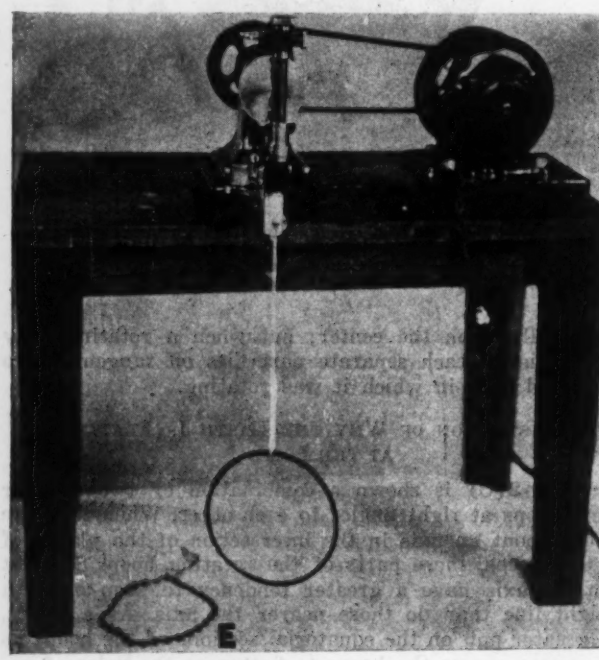

Fig. 5. Outfit for rotating a ring to show that each particle in the ring tries to get as far as possible from the axis of rotation.

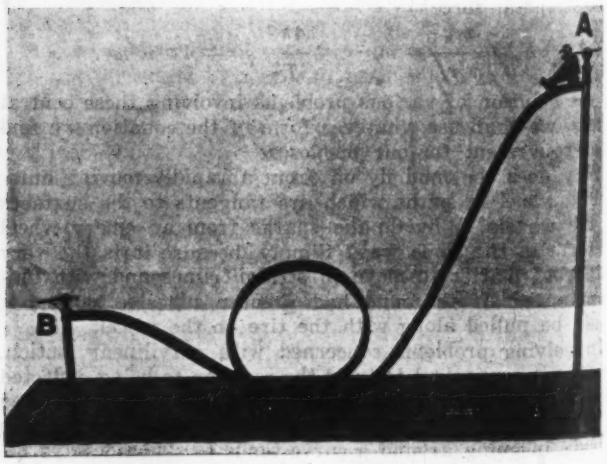

Fig. 6. For demonstrating "looping the loop."

the ring? The demonstration of this fact is to take a ride on a merry-go-round. The reason is found in the urge with which the rider tends to keep on in a path tangential to the curve in which he moves. The rider leans in so that the resultant of the two forces, the one just mentioned and the force of gravity, will be at right angles to the "banked" track on which the horse is running. This is shown in Fig. 7. It is a problem similar to the train rounding a curve.

Demonstration to Show the Rigidity of a Loop of Chain when Spun as a Ring.

Fig. 8 shows an electric motor taken from a Hoover vacuum sweeper. Its speed is over 6000 r.p.m. Attached to the shaft of the motor is a wooden disk about 8″ in diameter and about 1″ thick. The disk is nicely balanced and bound with strong wire. On this disk is placed a loop of heavy sash chain which will just slip onto the periphery of the disk. The chain and disk are set into rotation and, when going at full speed, the chain can be disengaged from the disk and will begin to roll along the floor or lecture table like a rigid ring. A strip of rubber extending from just under the disk and away a foot or two from it will help the chain start to rolling. The loop of chain can be made to bound up steps and do many things a rigid ring would do when rotating.

Demonstration to Show Effect of High Speeds in Cutting

Employing this same tendency for a moving body to keep on going in a straight path with uniform speed, one may use a sheet of good writing paper cut out to form a circular disk. In Fig. 8 (A) is shown a clamp for attaching such a disk of paper to the shaft of the Hoover motor. When up at a speed of 6000 r.p.m., a circular disk of paper will be pulled out into a plane, whose periphery on an 8″ disk will be traveling over 12,000 feet per minute. At this speed, the paper disk may be used as a buzz saw for cutting paper and light woods.

Demonstration for Quantitatively Measuring the Tendency of Matter to Go Off Tangentially When Rotated

In this experiment a cylindrical mass m, seen in the frame R, Fig. 9, is rotated at such a speed that the force necessary to hold it at a fixed distance r from the axis of rotation is equal to the stretching Mg due to gravity. The latter is obtained by suspending the framework R as in (a) Fig. 9. Wieghts are added until the spring is elongated the same amount as in (b) Fig. 9. Hence there follows the equation:

$$(M + m)g = 4\pi^2 n^2 mr$$

where n is the speed of rotation in revolutions per *second*, m the mass of the object whirled, and r the distance from the center of the cylinder m to the center of the axis of rotation.

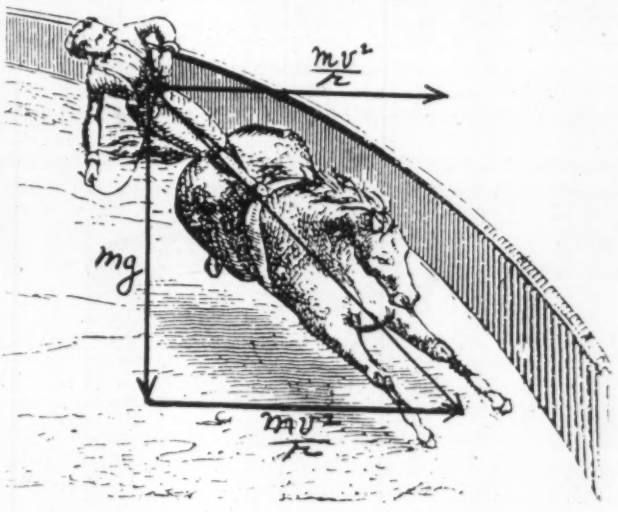

Fig. 7. The bareback rider. Why does he lean inward toward center of curvature?

Center of Mass

In connection with the motion of a body, whether translatory or rotatory, there is one point in the body which is of considerable importance. This is the center of mass or the center of gravity. The center of mass is that point which represents the mean position of the material in the body. Thus in a sphere of uniform density its geometrical center is its center of mass. If a force is directed straight at the

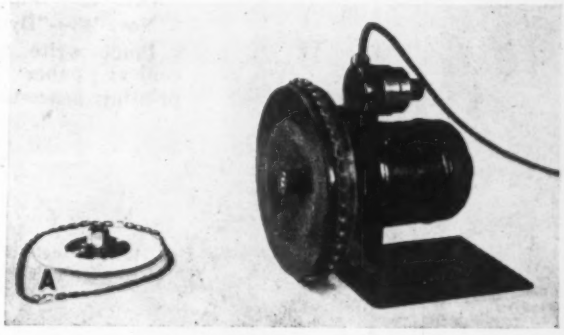

Fig. 8. A loop of chain is set spinning so that all parts are urged tangentially to the periphery of the spinning wheel and the chain behaves as a rigid ring.

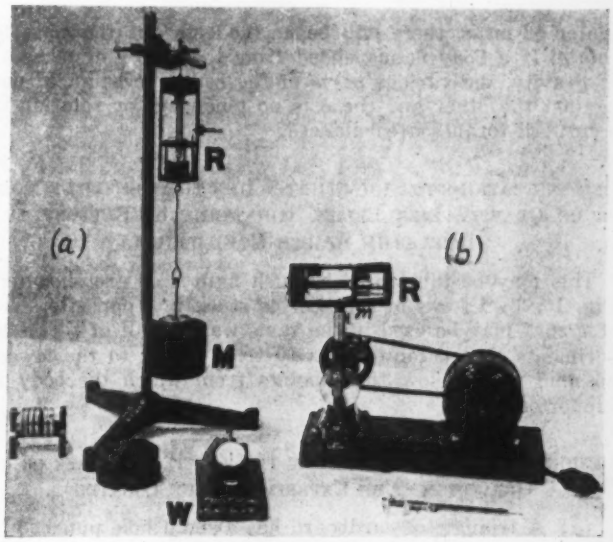

Fig. 9. Two springs are shown in this photograph: (a) The spring is stretched by the force of gravity; (b) The spring is stretched by centripetal force.

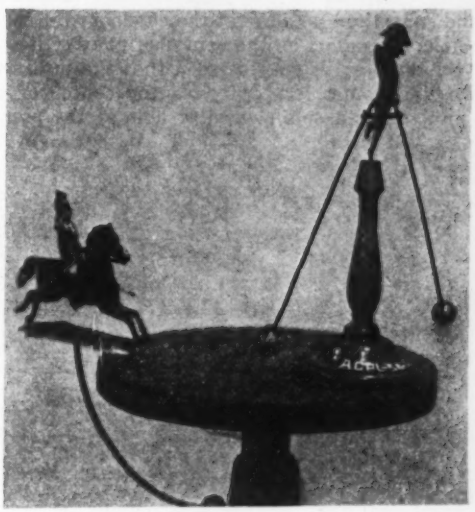

Fig. 10. Figures in equilibrium because their centers of gravity lie below their points of support.

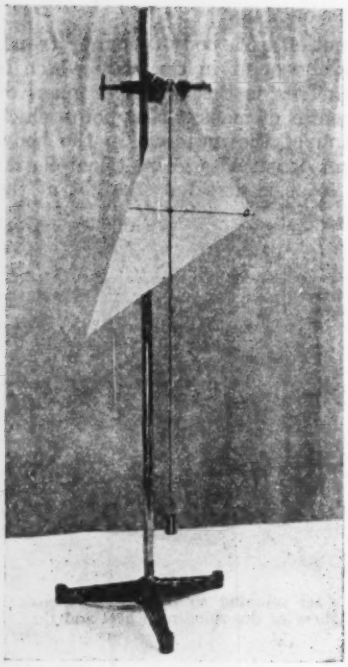

Fig. 11. A triangle of cardboard has its center of gravity located.

LORD knows how Dr. Williams finds time to write these articles in spite of his extra duties—we don't! Maybe it's because the hit they've made spurs him to find time. In reply to numerous inquiries, here are his preceding articles:

Dec. '42—"Metrology, the Science of Measurement."

Mar. '43—"Principles of Mechanics."

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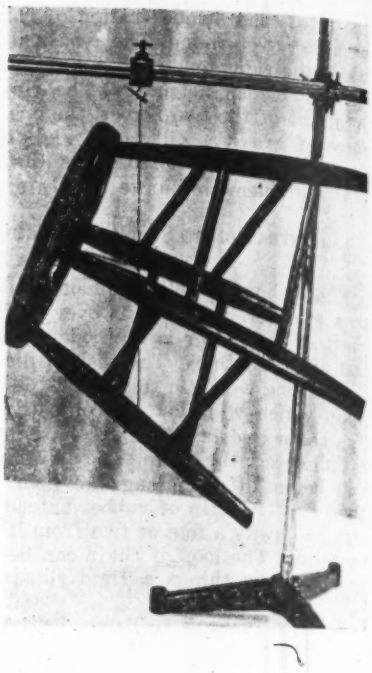


Fig. 12. Finding the center of gravity of a stool.

center of mass, there will be no tendency for the mass to rotate. If a body is suspended from the center of mass or of gravity, the various parts of the body are balanced one against the other and there is no tendency for rotation to occur. All torques are balanced.

Demonstrations to Show that When the Center of Mass or of Gravity Lies Below the Point of Support the Body is in Stable Equilibrium

This may be illustrated by such figures as are shown in Fig. 10. Two forks or two knives stuck into opposite sides of a cork may be used in the same way. In all of these experiments the center of gravity tries to get to the lowest possible point below those points from which the body is supported.

Demonstration to Show How the Center of Mass or of Gravity may be Experimentally Located

(a) A triangle of cardboard has a small hole punched in each angle as near the point as possible. Fig. 11. Suspend the triangle by hanging it on a steel knitting needle from one end of these holes. Directly in front of the triangle, hang up a plumb line chalked with red chalk. When the two are at rest pinch the line to the card at their lowest common points and snap the line against the cardboard. Repeat from another hole. Inasmuch as the center of gravity lies directly beneath the support, it may be seen that the intersection of these two lines must locate for us the center of gravity. With a punch, cut a small circular hole at the point of intersection of the two lines and when the triangle is supported on the knitting needle, it will be found to be in balance in any position in which it may be turned.

(b) The center of gravity may be outside of the material part of the object and yet can be found in the same way. This may be demonstrated by an ordinary laboratory stool suspended by two different strings but having a common point of intersection. This is shown in Fig. 12. By means of an auxiliary arm with a depression in it, this depression may be placed where the intersection of the two cords occurs, and the stool will be found in equilibrium around that point.

(c) A meter stick can be balanced on a knife edge and its center of gravity found.

The center of gravity is the point about which a body will rotate without wobbling. Its location with respect to the axis of rotation is highly important in machinery rotating with high speeds. If it is off center, the vibrations become terrific. One realizes this if a single blade breaks off from the fan cooling the engine of one's automobile. The vibrations which ensue are as though a giant was shaking the whole car. To remedy this matter of vibrations in high-speed rotation, careful balancing of the rotating parts is first made and then some adjustment is made in the bearings or for the machine as a whole so that the rotating part can spin about its own center of mass, for this is what every rotating body naturally tries to do. In our automobiles the engines are mounted on rubber pads. In a cream separator, rubber gaskets are put around the bearing collar through which the shaft of the swiftly turning bowl spins.

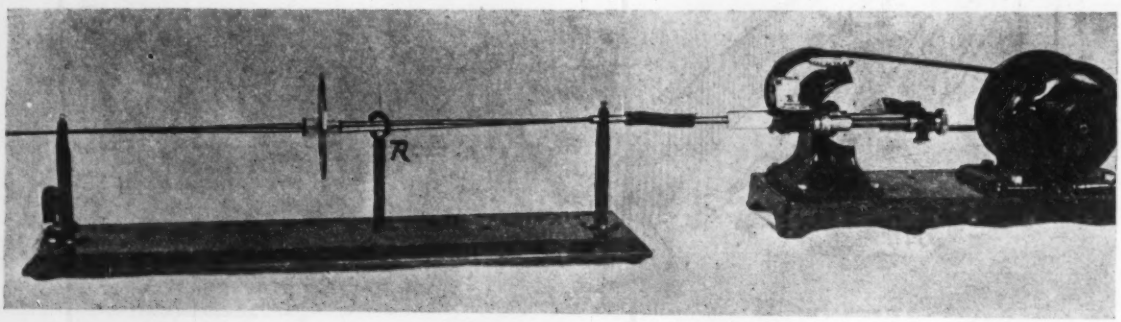


Fig. 13. A brass disk is mounted "off center" on a flexible shaft. When spinning, the disk and shaft spin about their common center of mass and without undue vibration.

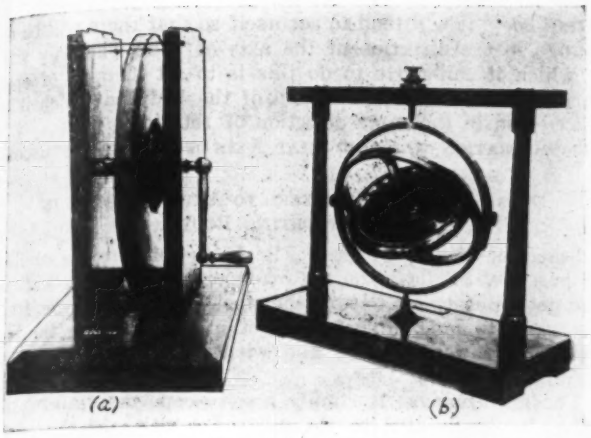


Fig. 14. A gyroscope (*b*) and a device known as a spinner (*a*) for setting the wheel of the gyroscope into rapid rotation.

Demonstration to Show How a Rotating Body Tries to Spin About Its Own Center of Mass

In Fig. 13 a brass disk, distinctly "off center," is mounted on a flexible shaft of spring brass. The disk is so much off center that it turns of its own accord so that the center of mass hangs below the shaft. The disk is 2½″ in diameter mounted ¼″ "off center." The flexible shaft is ⅛″ in diameter and 20″ long, mounted on ball bearings. By means of the variable-speed drive shown in the figure, the disk can be speeded up and kept going smoothly. It will be observed, however, that the shaft is whipping around in order for the high-speed disk to run smoothly. The whole rotating system swings about its center of mass and so runs smoothly. A guard ring *R* is attached to prevent the disk from whipping out of control when being started.

The Gyroscope

When a linear velocity is changed in direction, a linear acceleration occurs in a direction at right angles to the instantaneous linear velocity. The preceding demonstrations have indicated this fact. Similarly, when the direction of an angular velocity is changed, an angular acceleration occurs in a direction at right angles to the instantaneous angular velocity. This latter effect is to rotatory motion what the first is to translatory motion. To produce the first effect a force is required and to produce the second a torque is necessary.

The demonstrations which follow will show some of the effects when we change the direction of an angular velocity.

Demonstration of the Principles of a Gyroscope

Fig. 14(*b*) shows a gyroscope mounted in a Cardan suspension so that when the disk is set to spinning by means of the spinner (*a*) the axis of spin of the gyroscope may be set in any direction desired. The outstanding property of a gyroscope is to maintain its axis of spin in a fixed direction. Set the axis of spin horizontal and attach a weight at one of the ends of the axis—which means that a torque is applied to the axis of spin. Immediately, the gyroscope begins to precess; that is, the axis of spin begins to move around in a horizontal plane. Here we see that a change in the direction of angular speed gives rise to an angular acceleration which is at right angles to the direction of angular speed.

Fig. 15 shows a bicycle wheel, with a lot of wire wound about the rim and nicely balanced, used as a gyroscope. Its effectiveness lies in the way it can be handled in all sorts of ways. By suddenly changing the direction of the axis of spin, one can feel the torque suddenly put on the wheel to produce precession.

All spinning wheels—such as the flywheel of an automobile engine, the propeller of an airplane, the wheels of a locomotive—act as gyroscopes when rotating. It is a common experience for a car traveling at a good speed that if its front end is suddenly lifted and the axis of spin of the flywheel changed, the car as a whole will turn at right angles to the direction in which it is traveling. A sudden nosing down or up of a single-engined airplane causes a precession of the propeller blades and so the airplane swings either to the left or to the right, (A), Fig. 15. In the early days of the old Gnome engines, when the cylinders themselves were revolving, the torques to produce precession were enormous and many accidents occurred before it was discovered what was the matter. A locomotive traveling around a curve in a clockwise or counter-clockwise direction has its massive drive wheels acting like huge gyroscopes. As the direction of their axes of spin change in going around the curve, the direction of precession is always to make the engines tip over outward from the curve. These torques are enormous and help to account for some accidents.

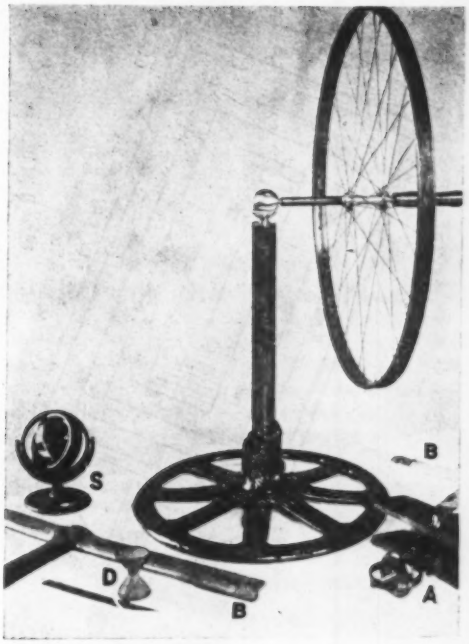


Fig. 15. A bicycle wheel used as a gyroscope.
(A) Model airplane with small gyroscope in place of engine.
(B,B) Boomerangs. (D) Diabolo. (S) Model of Sperry gyroscope.

Wherever the direction of the axis of spin of a gyroscope is changed, a torque is set up to produce precession. Consequently, if a spinning gyroscope is placed on another ro-

Fig. 16. Demonstrating the gyrocompass.

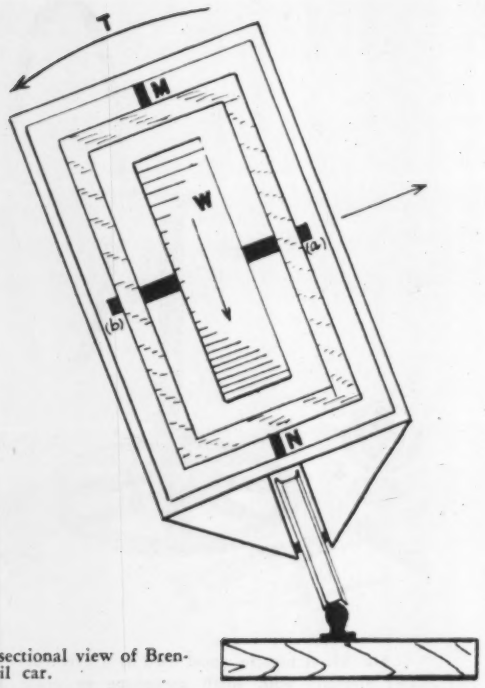


Fig. 17. Cross-sectional view of Brennan's mono-rail car.

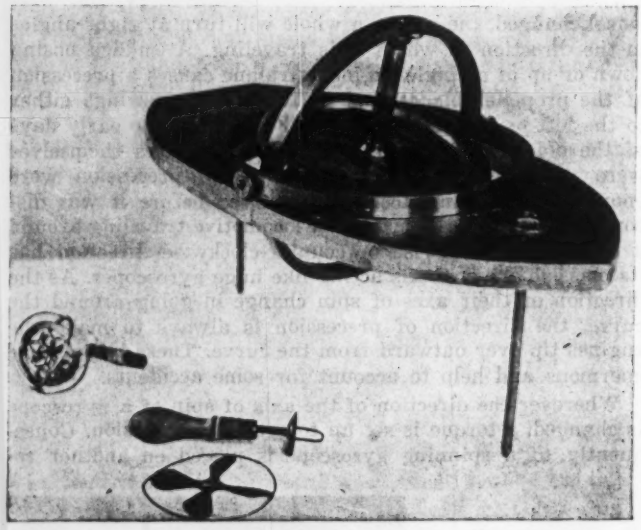


Fig. 18. Showing the stabilization of a boat.

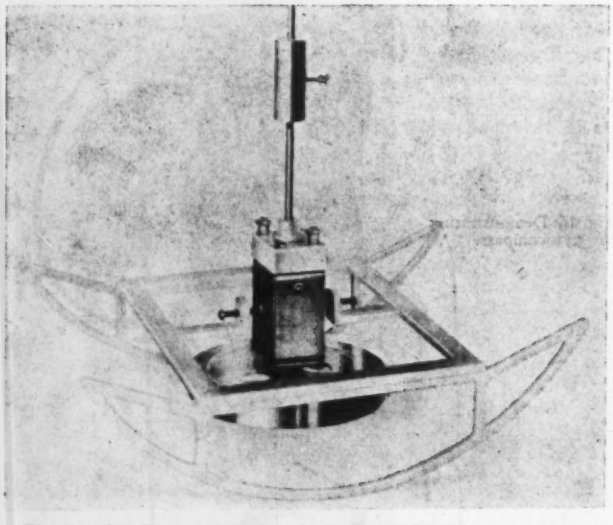


Fig. 19. Another arrangement of an electrically driven gyroscope to show how the rolling of a boat is prevented.
(Courtesy Scientific Apparatus Co.)

tating body, it will tend to set itself so that there will be no change in the direction of the axis of spin. The only way in which it can move to do this is to set its axis of spin parallel to the axis of rotation of the body on which it is placed and in the same direction of rotation.

Demonstration to Show that Axis of Spin of Gyroscope Does Set Itself Parallel to Axis of Rotation of Supporting Body

Start the bicycle wheel in Fig. 15 to spinning as rapidly as possible. Sit down on a turn-stool as shown in Fig. 16 and get an assistant to turn the stool. Immediately one feels the wheel turning in such a direction as will bring the two axes of rotation parallel and with the same direction of turning.

The gyrocompass is simply a gyroscope maintaining its axis of spin parallel to the axis of rotation of the earth and in the same direction and thus pointing due north.

The converse of this experiment is to sit quietly on the turn-stool as in Fig. 16 and, with the bicycle wheel spinning, rapidly raise the bicycle wheel over one's head using a stiff arm movement. Now the person on the stool and the stool are rotated because of the torque developed by changing the direction of the axis of spin of the gyroscope.

The gyroscope is being used for stabilizing boats, airplanes, and all sorts of machinery. The old monorail car was a practical application of the principle of the gyroscope.

Demonstration of the Mono-rail Car

Some years ago, Brennan devised a mono-rail car which was kept in an upright position by a large spinning gyroscopic wheel, W, Fig. 17. The front edge of the spinning gyroscope wheel W is moving downward as indicated. When the car begins to tip in the direction shown by the arrow T, the gyroscope begins to precess about its vertical axis MN in such a direction that the end of the axis (*a*) moves forward toward the reader. If now the angular velocity of precession is increased, i.e., accelerated, positively it will cause the end (*b*) of the axis of spin of the gyroscopic wheel to raise off of its bearings and throw the entire weight of the large wheel onto the end (*a*) of the axis of spin, or it puts the entire load of the gyroscope on the up side of the car which brings it back to level once more. The essential feature of this car was the Brennan device for accelerating the precessional movement. This can be done by mercury level contacts or analogous devices. If the car tips in the opposite direction the reverse process goes into action. Thus far, this means of transportation has not passed to the practical stage in its development.

Demonstration of the Stabilization of a Boat by Means of a Gyroscope

Fig. 18 shows a wooden platform supported on two pins. This is to serve as a model of a boat. In the middle of the boat is cut a circular opening in which is set a gyroscope with a Cardan suspension. The axis of spin of the gyroscope is vertical and the other axis of the Cardan suspension is at right angles to the keel of the boat. If the boat starts to roll, that will mean changing the direction of the axis of spin and so a precession of the axis of spin. Because of the moment of inertia of the gyroscope which resists change in direction of spin, a counter-torque is put on the boat to prevent its rolling. Fig. 19 shows another form of apparatus for showing the stabilization of a boat.

In Fig. 15 are shown various games in which the principle of the gyroscope is used. The diabolo D is a spinning spool which may be thrown in the air. As it goes up or comes down it maintains its axis of spin in a definite direction and so may be caught on a cord between two sticks. Some boomerangs B are also shown. The boomerang is thrown with a spin and in flight it acts as a gyroscope. However, we must know something about Bernoulli's principle in order to understand why the boomerang will return to the thrower, so we shall leave the demonstration of them until a later article.

ELECTRON TUBES

Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER
Managing Editor, Power Plant Engineering, Chicago, Ill.

CHAPTER IX

METHODS OF CONTROL IN USING THYRATRONS

The process of explaining things on paper is not entirely satisfactory. Were these matters explained in the laboratory where the action of tubes could be demonstrated, there would be more diversion. When working with electrical apparatus there is always a chance of somebody making a mistake; connecting the 6-volt filament terminals of a tube across a 2000-volt plate transformer for example. Fireworks are always interesting. People drop things. The impact of a $200 electron tube on a concrete floor always has

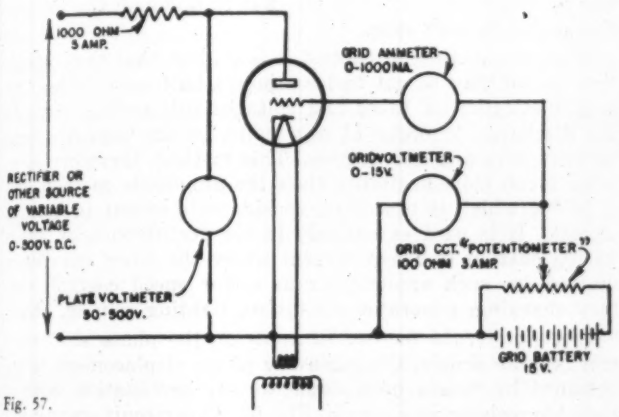

1000 OHM 5 AMP.
GRID AMMETER 0-1000 MA.
GRIDVOLTMETER 0-15V.
RECTIFIER OR OTHER SOURCE OF VARIABLE VOLTAGE 0-300V. D.C.
GRID CCT. "POTENTIOMETER" 100 OHM 3 AMP.
PLATE VOLTMETER 50-500V.
GRID BATTERY 15 V.

Fig. 57.

interesting repercussions. Instruments have a habit of burning out when ten or more times normal voltage is applied to their terminals and the physiological reactions resulting from the contact of human skin with radio-frequency conductors provide elements of interest which extend beyond the purely technical. Laboratory phenomena, though painful at times, are always intriguing.

On paper, however, accidents never happen; everything always works the way it is supposed to. Circuits are always shown connected correctly and, even if they are not, there never is any "fireworks." Short circuits have only an academic interest.

With this apology for the absence of the spectacular, we shall proceed with our discussion. If the reader really wishes excitement, it is suggested that he buy himself a couple of tubes and indicating instruments and try testing out some of the things we have been discussing. Nothing can take the place of actual experience and the results will be well worth the cost and effort.

Suppose, for example, that you had a little thyratron or grid-glow tube set up with a method for varying both the plate and grid potentials on it. A circuit such as shown in Fig. 57 would do nicely. A thyratron capable of carrying 0.1 amp. can be purchased for around $3.00. The circuit constants are all given so no difficulty should be encountered in hooking it up.

Even with such a simple circuit as this there is ample opportunity for diversion. In a circuit such as this (and this applies to any of the gas-filled tubes two- or three-element) the plate voltage should not be applied until the cathode has been allowed to heat up. If this is not done you may, or may not, have to buy a new tube after the first closure of the switch. Assuming that everything is connected properly, however, the grid voltage at which the discharge starts should be measured for various values of plate voltage from 50 to 500 volts. Aside from the sudden blue glow in the tube, breakdown will be indicated by the sudden fall of the plate voltage from the applied voltage to a 10- or 15-volt arc drop.

In observing the two voltages in each case it will be found that the grid voltage needed to cause breakdown depends upon the plate voltage. The higher the plate voltage, the lower the grid voltage required. If with 100 volts on the plate a grid voltage of 10 is required to cause breakdown, at 300 volts only 3 volts may be needed, while at 400 volts an actual negative potential may have to be applied to the grid to prevent breakdown.

Knowing this relation, the action of the tube under alternating potential instead of direct is more easily understood. With a fixed grid voltage the tube will break down at that instant during the beginning of the positive half-cycle when the value of the plate voltage added to the fixed grid

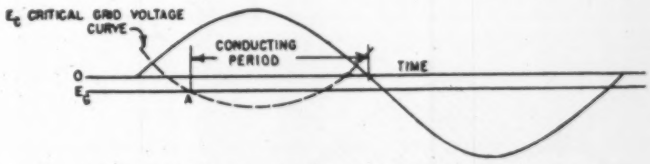


Fig. 58. The dotted curve is known as the critical grid voltage curve. Grid potentials equal to, or more positive than Ec render the tube conducting; conversely, grid potentials more negative than Ec prevent conduction.

voltage already existing is sufficient to ionize the gas in the tube. In other words, with alternating current, the amount of grid voltage needed to initiate the discharge depends upon the instantaneous value of the plate voltage. Thus, as explained in the preceding chapter, with the application of alternating potential across the cathode and plate, current can be made to flow in the plate circuit during a portion of the positive half-cycle, depending upon the value of fixed grid potential, but in no case can the flow period be cut to less than a quarter of a cycle.

It was also shown, however, that by introducing a "time" element in the application of the grid voltage, with respect to the instantaneous value of the alternating potential across the plate circuit, the flow period could be cut to less than a quarter of a cycle.

Amplitude and Phase Shift Control

These two cases imply two general methods of operation: the first an amplitude method and the second a phase shift method. In the amplitude method the voltage applied to the grid is varied until the discharge starts or with a fixed grid voltage the plate voltage is increased until the discharge starts. This has all been fully described.

The phase method implies the application of alternating potential to both grid and plate. Consequently, the operation of the tube under such conditions is somewhat different from that when the grid potential is negative.

Before this phase shift method is considered in detail, a few words more about the general characteristics of these tubes may not be amiss. If a circuit such as in Fig. 57 is available, so much the better, for then actual readings can be used. However, in the absence of such a circuit you can assume that what is stated here is true. If the values of grid voltage at which breakdown occurs under various values of plate voltage are plotted on the same wave diagram with that of the plate potential, a curve of "critical" grid voltages will be obtained as shown in Fig. 58. Such a curve (E_c) is known as a critical grid voltage curve.

Grid potentials equal to, or more positive, than E_c will render the tube conducting, and conversely, grid potentials more negative than E_c will prevent conduction. Therefore,

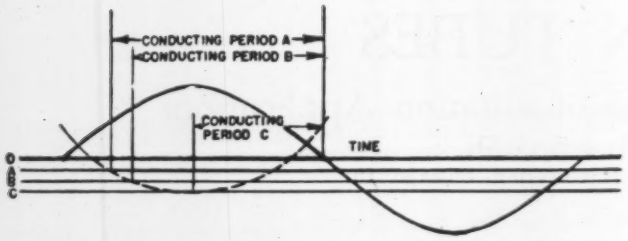


Fig. 59. Diagram showing the manner in which the conducting period can be varied by the application of different grid voltages, A, B, and C

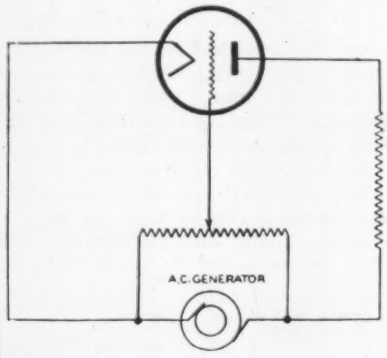


Fig. 60. In this circuit alternating potential is applied to both grid and plate. The grid and plate voltages are in phase and the tube action is not materially different from that with direct potential.

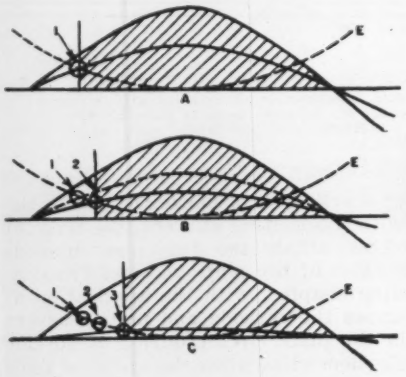


Fig. 61. Diagrams showing the effect of three different grid potentials upon the conduction period.

if at any time during the cycle the grid becomes more positive than E_c the discharge will start. The grid will then lose control and the tube will remain conducting until the discharge is stopped by the lowered plate voltage at the end of the cycle. If, for example, a constant voltage, represented by E_c in Fig. 58 is applied to the grid, the tube will become conducting at the point *A* in every positive half-cycle and remain conducting until the end of the positive half cycle.

This, it will be obvious, is only another way of explaining the action considered in the preceding chapter. The fraction of the cycle between the point *A* and the next voltage zero, that is, the "conduction period," can be controlled by arranging the grid circuit so that the grid voltage curve intersects the critical curve at any desired point between zero and 90 degrees. In Fig. 59 is shown the manner in which the conducting period is varied by the application of different grid voltages, *A*, *B* and *C*. In no case, however, can the conducting period be reduced to less than a quarter of a cycle.

Phase Shift Control

If, instead of direct potential, alternating potential is applied to the grid by means of a voltage-dividing arrangement as indicated in Fig. 60, the action of the tube will not differ materially from that described with direct potential. For with this arrangement the grid and plate voltages are in phase, both increasing and decreasing at the same time and it is not possible to cut the flow of current to less than a quarter of a cycle. So long as the two voltages, grid and plate, are in phase this limitation in operation exists. This method, i.e., the use of alternating potentials in phase, is still an amplitude method of control.

This is shown graphically in Fig. 61, *A*, *B* and *C*. These diagrams show the effect upon the conduction period of three different values of grid potential. The critical grid voltage curve E_c (shown dotted) is of course fixed by the structure of the tube and is the same in each of the three diagrams. The grid voltage is varied in each of the three cases, so that the curves representing these grid voltages cut the critical grid voltage curve at different points, 1, 2 and 3, as shown. As a consequence, the conduction period is different in each of the three cases.

Suppose now that instead of merely varying the amplitude of the grid voltage wave, it is shifted sideways along the time axis of the diagram as indicated in Fig. 62, *A* to *E*. These show five different conditions of phase displacement between the grid voltage and the plate voltage. At *A*, the two voltages are in phase and under this condition the grid voltage curve cuts the critical grid voltage curve at a point 27° from the beginning of the cycle. At *B* the plate voltage leads the grid voltage by approximately 18° and as a result of this change in phase relation the conduction period does not begin until 32° after the start of the cycle. The remaining diagrams show further successive phase shifts which will be quite obvious. Their effect is to diminish the conduction period in each case.

With this method of control it is evident that the conduction period may be cut to less than a half-cycle, indeed by proper selection of tubes and voltages this method permits the discharge to occur at *any* point in the positive cycle between zero and 180 degrees. This method, therefore, provides much more flexibility than the amplitude method and it is one which is used to a considerable extent in control circuits. It is used extensively in the rectification of alternating current to direct current where the direct current is desired for such applications as motor speed control, battery charging, generator excitation, lighting control, etc.

Electrically, the method of applying the phase shift control is quite simple, the necessary phase displacement being obtained by means of a capacitor in combination with a variable resistor as shown in Fig. 63. This circuit containing only a single tube provides half-wave output. The power circuit is from the center tap of the transformer, across the cathode to the plate, through the load and back to the trans-

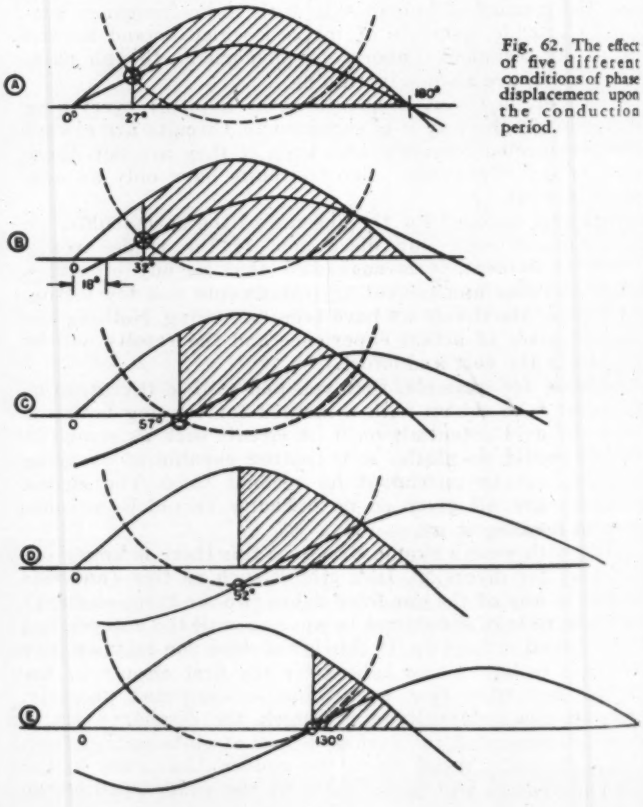


Fig. 62. The effect of five different conditions of phase displacement upon the conduction period.

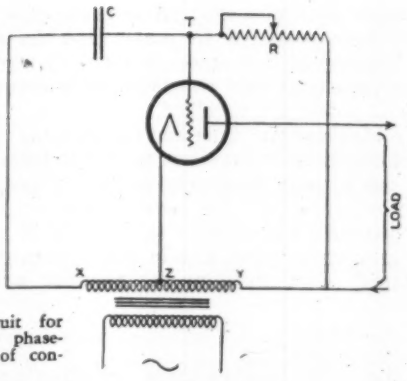


Fig. 63. Circuit for obtaining the phase-shift method of control.

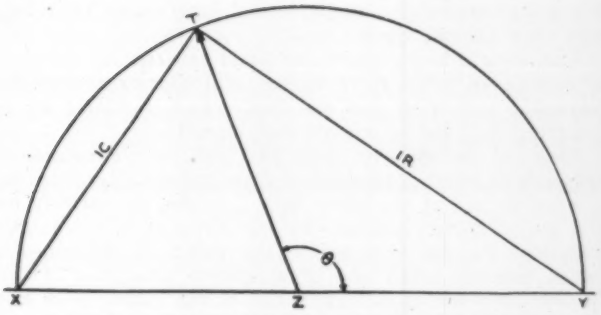


Fig. 64. Vector diagram of the voltages in the phase shift control circuit. Note—the points indicated by letters on this diagram represent the points on the circuit diagram of Fig. 63.

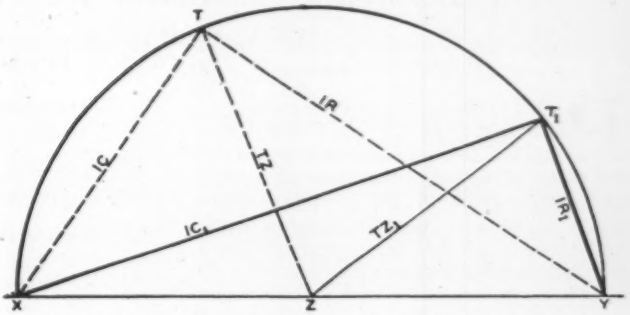


Fig. 65. Showing changed vector relations resulting from a change of resistance.

former at *Y*. The control circuit *X C R Y* requires very little current. It consists of a fixed capacitor *C* and a variable high resistance *R* bridged across the power transformer winding. The grid of the tube is connected between *C* and *R* as shown.

The operating principle underlying this circuit is quite simple. It is based upon the fact that the current in an a-c. circuit containing only a capacitor always leads the impressed electromotive force by 90° while, in a circuit containing only resistance, the current is always in phase with the impressed electromotive force. The control circuit *X C R Y* in Fig. 63, it will be noted, is divided into two parts through the grid cathode circuit of the tube, one side containing only the capacitor while the other side contains only the resistor. The currents in these two circuits are displaced in phase.

The action of the circuit is best explained by means of a vector diagram such as that shown in Fig. 64. In this diagram the points *X*, *T*, *Z*, and *Y* correspond to the points similarly marked in Fig. 63, and the lines between them are the vectors representing the voltages in the circuit between these points. Thus, the line *IR* represents the voltage drop between the points *T* and *Y* in the circuit.

The total voltage drop around the control circuit is, of course, the vector sum of the component voltage drops in different parts of the circuit. The voltage drop across the circuit, furthermore, must be equal to the impressed voltage. The impressed voltage is that delivered by the transformer, or that acting between *X* and *Y*.

Thus the impressed voltage *XY* is represented by a line connecting the ends of the vectors representing the voltage drop in *XT* and *TY*, which are drawn at right angles to each other because they are always 90 degrees out of phase. The vector *ZT* represents the grid voltage vector.

Knowing that the length of the line *XY* must remain fixed (because the transformer voltage is constant), it will be obvious that when the length of the line *IR* is varied, the length of the line *IC* also will vary, becoming longer as *IR* becomes shorter. Also, it will be evident that as the ratio between the lengths of *IR* and *IC* is changed, the point *T* (their junction) will trace a cemi-circle as shown. Furthermore, since the point *T* is one end of the vector *TZ* and since the point *Z* is fixed, it will be seen that the angular position of *TZ* with respect to *XZ* and *ZY* will be different for each different position of *T* on the semi-circle. Hence, as the value of *IR* is increased by manipulating the variable resistor *R*, the phase angle of the grid voltage increases with respect to the plate voltage, and the grid voltage wave is slid to the right as shown in the diagrams in Fig. 62. (See also Fig. 65.) It is all quite simple—much less complicated than it sounds. The vector relations should be clearly understood, however, and that is why they have been discussed in some detail here. If one will only remember that the voltage across the capacitor and the resistor are 90 degrees apart, no trouble should be encountered in understanding the action. Combining these voltages vectorially gives the total voltage across the transformer.

If *R* is made large, the phase difference between the grid and plate voltage is great and under these conditions the conducting period per cycle is shortened; when, however, *R* is made zero, the grid and plate voltages become in phase and the tube will conduct current throughout the whole of the positive half-cycle.

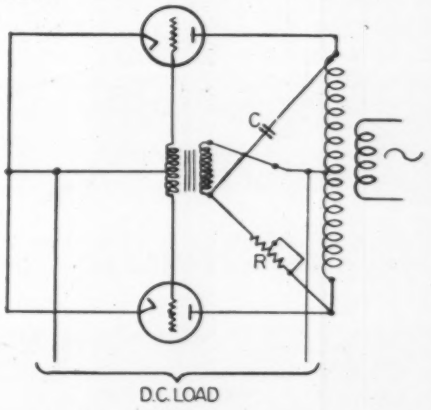


Fig. 66

By this method of control, therefore, it is possible to control the d-c. output of the tube to any desired degree. The circuit shown in Fig. 63, of course, gives only half-wave control, but this can easily be explained into a full-wave controller by the use of two tubes as shown in Fig. 66.

If desired, the phase shift control circuit may be made up of an inductance and a resistor instead of a capacitor and a resistor. In either case the action is the same except that in one case a leading voltage is produced while in the other a lagging voltage results.

Phase Shift Control Has Many Applications

It must be obvious that circuits such as these are very useful and have a variety of applications. The change in resistance through which the control is effected may be accomplished manually, by manipulating a dial, or automatically by any varying process or function, or electrically, by means of other tubes. The change in resistance for example may be brought about by means of a photocell through the action of light.

In the case of an a-c. generator, the field current might be supplied through a set of gaseous discharge tubes of this type and, by simply providing an arrangement whereby the resistance is varied by the change in terminal voltage, an electronic voltage regulator results. Such voltage regula-

tors are commercially available and have many advantages over conventional types.

Numerous other applications could be cited but these will be considered later. Here we are still concerned with fundamental principles and we must avoid confusion by not becoming involved in complicated circuits.

As must be obvious from the last four chapters, the presence of gas in a thermionic tube entirely alters its characteristics and at the same time provides an entirely new and useful device, suitable for use alone or in combination with high-vacuum type tubes. The principal difference between gaseous tubes and high-vacuum tubes lies in their current-carrying capacities. Whereas the currents in high-vacuum tubes are measured in milliamperes, in gaseous tubes they are measured in amperes—even hundreds of amperes. Because of this, gaseous tubes find great application in the industrial field where heavy currents and large quantities of power are involved.

Both the high-vacuum type and the gaseous type of tubes are important, however, and one must not form the impression that one type is used only for heavy power purposes and the other type only for light power or control work. In many instances the gaseous tube would be useless without the high-vacuum tube, and in many circuits both types will be found, each fulfilling its peculiar and necessary function.

A Time-saving Calculator for A-c. Work

By V. W. PALEN
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

PLANT engineers and electricians will find this KVA-KW-HP Calculator a useful gadget to have on hand. It saves much time in making routine calculations involving electrical capacities. It solves single-phase and three-phase problems expressed by the following formulae:

(a) Single phase

kva = volts × amps/1000

kw = volts × amps × P.F./1000

hp = volts × amps × P.F./746

(b) Three phase

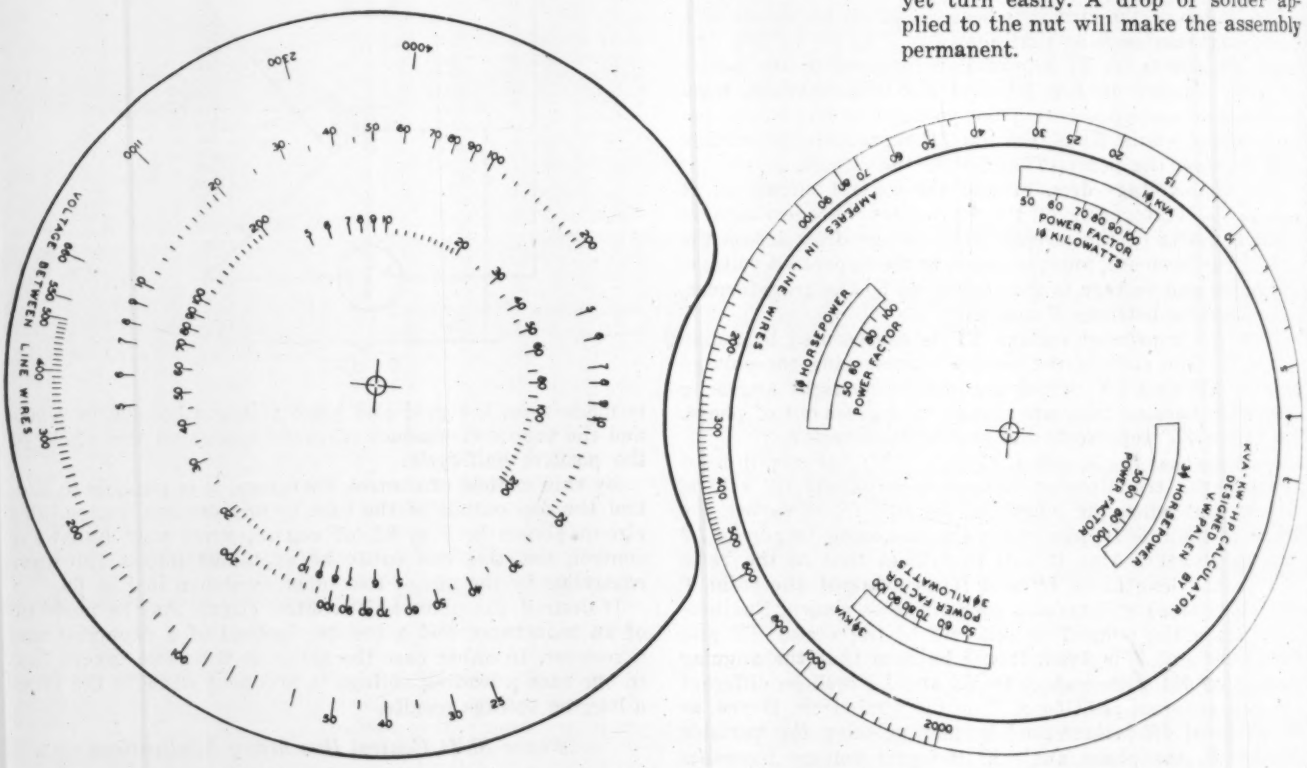
kva = √ 3 volts × amps/1000

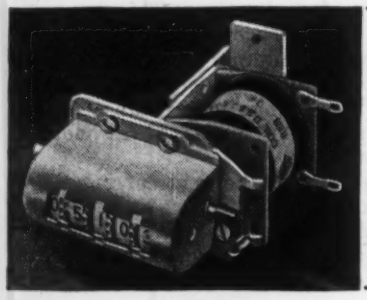
kw = √ 3 volts × amps × P.F./1000

hp = √ 3 volts × amps × P.F./746

The range of the calculator, 5 to 200 (kva, kw or hp, as the case may be), can be extended easily to cover a range of 50 to 2000 merely by multiplying all values by 10. It can be used to find kva, kw or hp from known values of amperes and volts; similarly it will determine amps for given values of voltages, kva, kw and hp. Thus, knowing the size motor to be installed, an electrician can quickly determine amps; from this he knows what size wire to use for the circuit. Conversely, having read amps at transformer terminals, the calculator tells what load, in kva, the transformer is carrying.

To assemble: — Cut out both disks (also small windows) and mount on cardboard with rubber cement. Punch the center holes carefully, then insert a small brass bolt in the holes. Washers, if used will save wear and tear on the paper. The bolt should be tightened so that the disks will hold their setting, yet turn easily. A drop of solder applied to the nut will make the assembly permanent.





Correll & Correll High Speed Electric Counter

Ideal for all counting and data accumulation work . . . production . . . control . . . developmental . . . psychological . . . etc. Standard voltage is 110 volts 60 cycles, but other voltages from 6 to 220 A.C. or D.C. are available at 75c additional. G&G HiSpeed Electric Counters, $4.10 each FOB factory.

Counter is compact, sturdy, well engineered. Counts up to 700 per minute. Operates on non-reset principle . . . counts to 99,999 and then repeats. Draws only 4 watts. Counter mechanism totally enclosed . . . large figures easily read through plastic window. Mounts and operates in any position. Size 3 1/8" by 3 1/8" by 1 5/8". Cadmium plated. Special bracket to permit mounting at right angles is recommended at 26c extra.

Correll & Correll
CHICAGO HEIGHTS, ILL.

Mathematical Analysis of Special Electric Control Circuits*

By R. S. ELBERTY, Jr.

Consulting Engineer, New Britain-Gridley Machine Div., New Britain, Conn.

THE electrical drive for machine tools is largely control; we no longer just start and stop motors. Our main problem is in the selection and grouping of the electrical parts of a machine. While the nature of these parts is varied, they can be classified in four groups according to function: (1) *Contacts* establish the condition of the circuits; (2) *conductors* carry the electric energy; (3) *operated members* change electricity into other forms of energy, and (4) *conversion devices* change electric energy into more useful forms.

Pushbuttons, timers, magnetic contactors, are all examples of electrical contacts used on machinery. Cable and wiring harness are examples of late refinements in electrical conductors. Motors, solenoids, electrical heaters, are operated devices we all use to change electric into other forms of energy. Transformers and rectifiers are conversion devices used on machine tools.

Electrical contacts determine the conditions of the circuits and there is a close relationship between the functions of a controller and the number of contacts used. A good controller should not have too few or too many contacts, and the control criterion will enable the control designer to make a simple check on his design.

Free contacts are those that are not mechanically interlocked with other contacts in the same circuit. In any one circuit, the first contact furnishes two conditions; circuit closed, and circuit open. Another contact added in series with the first cannot add any conditions to the circuit when the first contact is open. With the first contact closed, however, the second contact adds a condition when it is opened. Suppose the second contact is added in parallel with the first. Now, this second contact can add no conditions to the circuit if the first contact is closed, but can add one condition if closed when the first contact is open.

The same anlaysis holds for free contacts in combined series and parallel circuits; the number of circuit conditions being one plus the number of contacts, provided all contacts are free contacts.

For free contacts, the control criterion is: C (conditions) $= Nf$ (free contacts) $+ 1$.

All control circuits do not use free contacts. Contacts may be restrained by mechanical or magnetic interlocking with other contacts in the same circuit. Restrained contacts are applied for sequencing or interlocking machine functions. Contacts that are restrained so that only two positions or combinations are possible, may be said to operate under first-order restraint. The two-pole snap-action limit switch is a common example of such contacts. High-order restraint contacts have three or more positions, drum switches and timing relays being examples of high-order restraint contacts used on machine control.

The limiting action of a first-order restraint contact prevents one function in the control circuit to which it is applied. It can be shown that on all circuits using one or more first-order restraint contacts the control criterion is: $C = Nf + Nr$.

High-order restraint contacts may act as free contacts, but they can do no more than this. For high-order restraint but no first-order restraint contacts in the circuit, the condition may therefore equal the number of contacts, or one plus the total number of contacts: $N \leqq C \leqq N + 1$. This is the true general expression of the control criterion.

There are several interesting exceptions to the control criterion. A Navy valve operator control uses duplicate contacts on both sides of the line so that operation will be possible with grounds or short circuits in one line. If the conditions are accurately counted, the control criterion is met, but the conditions of grounds and short circuits must be considered to do this. Otherwise there are too many contacts for the conditions.

Sometimes a series resistor is used with two or more pilot lights, the lights being controlled by parallel contacts. When all lights are shorted out, the resistor acts to prevent a short circuit, that is, as an open contact. When the lights are lit, the resistor acts as a closed contact. Since the resistor modifies the circuit as a contact would, should be considered as a free contact in applying the control criterion.

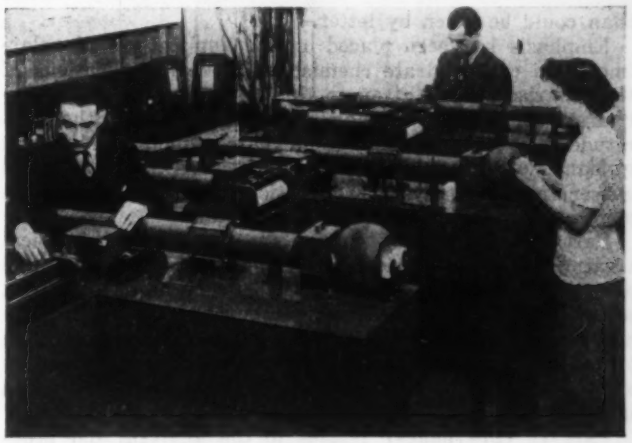
The control criterion is a simple check that can be applied to a control design. If the control will meet the criterion, then it will function as intended if wiring is designed properly. If there are too few contacts, then the control will not meet all conditions it is intended for. The controller with too many contacts is more complex than required. It may cause faulty operation of the machine by adding unexpected conditions. The control criterion gives the electrical designer a method of checking his own work.

*From a paper presented at the Machine Tool Forum held at the Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Instruments in the War Effort

Spectrophotometers for Camouflagers

HELPING our fighting forces to deceive enemy observers, the recording spectrophotometer instrument is being used to match camouflage colors so that they cannot be detected by the enemy's infrared cameras. Camouflaging, an art which depends on the use of color, suffered a major setback when the infrared camera was developed.



Two objects which to the eye have the same color may photograph differently with the special film. The camouflage artist cannot judge from the visual appearance of a color how it will look to the infrared camera. But now the General Electric Co.'s spectrophotometer has come to the aid of the camouflager. It gives him a measure of color — both visible and invisible — which puts him on an equal footing with the infrared camera. For by determining the amount of infrared radiation reflected by any paint or other material he wants to use, he can tell what effect that material or color will have on the plate of the infrared camera. The G-E recording spectrophotometer was fully described in *Instruments*, March 1936, page 68. In the photograph herewith, some of these instruments are being inspected and tested before shipment to our Armed Forces.

X-ray Machines

USE of x-ray machines is greater now than at any other time in their history. At each Army induction center thousands of x-ray pictures are taken each day to determine the physical fitness of the inductees. At Army receiving hospitals, x-ray machines enable surgeons to determine extent of injuries received in line of duty. In industry, new uses for x-ray machines are found every day. X-ray machines used in these vital services must be able to stand long hours of hard use under conditions far more severe than those of normal times. The responsibility of seeing that the Government and industry get the machines they need rests with the x-ray laboratory of the National Bureau of Standards. Here, the behavior of the machines is observed under the most severe conditions. Since improperly designed machines can be a source of danger to doctors and nurses, they are carefully inspected to determine whether or not the personnel in operating them are likely to be exposed to dangerous amounts of radiation or to the high voltages necessary to generate the x-rays required by modern techniques.

The requirements of the specifications under which the Army buys these machines are so severe that many machines fall short of them when first tested. In the event of a failure on the first trial, improvements can often be suggested by the Bureau, after which an improved model is generally submitted for further tests. The process continues until a safe x-ray machine is produced that will stand up under every exigency of intensive use. In this way the quality of the machines has been greatly improved.

"Polarimetry, Saccharimetry and the Sugars"

INCREASING applications of polarized light to the arts and sciences, especially in the field of carbohydrate chemistry, has led to many requests to the National Bureau of Standards for information. In *Circular C440*, by Frederick J. Bates and associates, an attempt is made to answer as far as possible such inquiries and to furnish information of a broader character and in greater detail than could be given by letter.

Emphasis has been placed on the applications of polarimetry in carbohydrate chemistry. Special applications of the polariscope are given in this Circular, because carbohydrate chemistry could hardly have developed to the magnitude it has attained in recent years without the aid and guidance of the polariscope; and because many inquiries concerning the analysis, preparation, and properties of the sugars have been directed to the Bureau.

Part I (115 pages) covers an original mathematical treatment of the physical phenomena and description and discussion of the physical equipment, such as polarimeters, saccharimeters, and accessory apparatus utilized in the study and applications of polarized light. The text is illustrated by many diagrams and photographs, accompanied by simple explanations of the physical concepts and deductions used.

Part II (275 pages) relates to the analysis and properties of sugar products, such as raw and refined sugars, honey and sirups. It includes an extensive discussion of polarimetric and chemical methods utilized for determinations. Sections are devoted to important physical properties: density, refractive index color, turbidity, viscosity, acidity, electrical conductivity, solubility and boiling point.

Part III (140 pages) is devoted to the preparation and properties of the sugars and their derivatives. It includes discussions of the optical activity of organic compounds and of the structures, configurations, and reactions of the sugars. Methods are given in detail for the preparation of 24 important sugars and for numerous sugar derivatives. The text is supplemented by an extensive table, which lists the important sugar derivatives and gives physical constants and literature references.

Part IV (9 pages) gives general information concerning the Standard Samples of sucrose and dextrose issued by the Bureau and concerning tests of equipment which the Bureau is prepared to conduct.

Part V (235 pages) contains 78 reference tables of numerical data and a resume of the work of the International Commission for Uniform Methods of Sugar Analysis and the United States Customs regulations governing the weighing, taring, sampling, classification, and polarization of imported sugars and molasses.

This 800-page treatise contains 150 numerical tables. The data given is certain of these tables have not been heretofore available. The numerous literature references should provide a rich source of information.

Copies of *Circular C440*, which is bound in blue buckram, are obtainable at $2.00 each from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Miniature Geiger-Muller Counter

NEW uses for Geiger-Müller counters, sensitive devices for measuring radiation, have been made possible by the development of counters of a size comparable to a hypodermic needle. As described in the February *Journal of Research* of the National Bureau of Standards (RP-1525), L. F. Curtiss has succeeded in making counters about 1½" long and only 1-32" in diameter. They are at least as sensitive per unit area as the larger counters customarily used. Individual pulses from these tiny counters are, surprisingly enough, much larger than those from larger counters.

These miniature counters are particularly useful in locating and measuring narrow beams of radiation, such as the beam of X-rays reflected from a crystal. They can also be used in the study of biological specimens by means of radioactive tracers. In such applications the radioactive substance is introduced in small amounts into the living organism and its subsequent distribution is studied. By using "hypodermic needle" counters this study could be made without destroying the living organism, and since the counter could be introduced directly into the tissue, the sensitivity of the measurement would be greatly increased.

The Instrument Mechanic's Blues

By ROYAL McGOWAN
Springfield, Ohio

Tune—"On the Road to Mandalay"

On the verge of desperation
When the instruments go bad
When you cannot seem to fix 'em
And you think you're going mad.

When you tear your hair and jabber
And you wish that you could cuss
And the boss drops 'round to see
Why you're raisin' such a fuss.

Then he nonchalantly asks you
When you're going to turn 'em in.
So you slap 'em all together—wrong;
Then tear 'em down agin.

On the verge of desperation
Tearin' hair and lookin'—Say!
I would rather sell tomatoes
On the road to Mandalay.

Instrument Societies

BALTIMORE INDUSTRIAL INSTRUMENTATION SOCIETY

Thirty-one members and guests attended the November 19, 1943 meeting of the Baltimore Industrial Instrumentation Society which was held at the Maryland Academy of Sciences, 2724 North Charles Street, Baltimore, Maryland, at 8:00 P.M.

The meeting was addressed by Mr. Harvey P. Rockwell, Chief of the Electrical Instruments Section, Radio and Radar Division of the War Production Board, Washington, D. C., whose subject was, "The War Production Board's Activity in the Industrial Instrument Field." A great deal of instructive information was given on the proper form to be used in obtaining a new instrument or part for a present instrument. He also discussed the history of flight instruments.

We also had with us Lt. Walter Gearhart, U.S.N., a guest of Mr. Rockwell. Lt. Gearhart is also a member of the Electrical Instruments Section of the War Production Board, having charge of instrument requirements of that department. He envisioned the vast possibilities of post-war instrumentation yet to be applied to industrial instruments from the unknown instruments now being used by the Armed Services of our country.

—CARL B. WILLNECKER,
Secretary

CHICAGO

An exceptionally large crowd attended the November meeting of the Chicago Society for Measurement & Control. This meeting was held on Monday night, November 1st, at the Graemere Hotel.

Speaker of the evening was Mr. George D. Litele of the Dodge Chicago Plant, Division of Chrysler Corp. Mr. Litele is Supervisor of the Engine Testing Laboratory at the above plant. The high lights of his talk were descriptions of several unique instruments which they found it necessary to develop themselves because of their inability to obtain such devices at the time these instruments were required.

The Chicago Society this year is scheduling its meetings in various parts of the city to facilitate and encourage attendance of those interested in the various sections. Judging by the attendance thus far, the plan is meeting with success.

—J. A. RIGGS

NORTHERN INDIANA SOCIETY FOR MEASUREMENT AND CONTROL

EDUCATION — FRATERNITY — DEMOCRACY

The November meeting of the Northern Indiana Society for Measurement and Control had a record attendance of fifty-two. We think this isn't so bad for our society that has been in existence only six months.

Mr. O. B. Wilson of the Brown Instrument Co. presented an interesting and educational talk on "Automatic Control." Mr. Wilson explained the different types of instruments and their selection for the process, taking into consideration the application problem, control medium, power source, reliability, flexibility, location where the instrument must operate, and cost. The lags in the different control processes and the types of automatic control were also ex-

INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	J. E. Eaton, 425 Peachtree St. N.E., Atlanta				
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	Dec. 17(D)	Maryland Academy of Sciences	Rayotube Pyrometry	H. L. Pfaffhausen, Leeds & Northrup Co.
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Jan. 3(B)	Phil Smidt, 1170 Indianapolis Blvd, Roby, Ind.	Automatic Control in Boiler Plants and in Processes	R. A. Ackley, Republic Flow Meters Co.
			Feb. 7	To be announced	Liquid Level Control	D. J. Bergman, Universal Oil Co.
			Mar. 6	To be announced	Furnaces with Controlled Atmospheres	N. K. Koebel, Lindberg Eng. Co.
Gulf Coast	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Tex.				
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control	N. E. Chance, 14 Glen Oakes Ave., Summit, N. J.				
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.	Dec. 28(B)	Churchill's Terminal Restaurant	Precise Time Measurement	C. H. Fetter, Pres. Am. Time Products, Inc.
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Illinois	Jan. 14(B)	Lake Hotel, Gary, Ind.	Installation and Application of Flowmeters	L. K. Spink, Foxboro Co.
			Jan. 19(B)	To be announced	Oil Refinery Instrumentation	O. G. Kaasa, Sinclair Ref. Co.
			Mar. 10	To be announced	Dev. of Perm. Magnet and Applications	C. A. Maynard, Indiana Steel Products Co.
			Apr. 14	To be announced	Film: "Approved by Underwriters."	
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, 712 Otis Bldg., Phila. Pa.	Dec. 17(B)	Engineers Club	Telemetering	Perry Borden, Bristol Co.
			Jan. 19(B)	Engineers Club	Measurement of pH and Conductivity	Dr. W. N. Greer, Leeds & Northrup Co.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.	Dec. 27(B)	Roosevelt Hotel	The Rotameter and its Secrets	Kermit Fischer, Pres. Fischer & Porter
			Jan. 24(B)	Roosevelt Hotel	Graphical Method of Process Analysis	J. G. Ziegler, Taylor Instrument Co's
			Feb. 28(B)	Roosevelt Hotel	Automatic Temperature Control	C. O. Fairchild, C. J. Tagliabue Mfg. Co.
			Mar. 27(B)	Roosevelt Hotel	Principles of Automatic Temperature Control	J. C. Peters, Leeds & Northrup Co.
St. Louis	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co.				
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 2, no dinner.

plained. Screen projections were presented along fith the talk which everybody enjoyed.
—RAY W. SCHREINER, *Corresponding Sec.*

PHILADELPHIA

Our Quiz Board came through with flying colors in our first attempt at a Question and Answer Nite—the November 17 meeting.

The group of experts, consisting of Messrs. M. H. White of the Atlantic Refining Company, W. D. Young of the Barrett Company, Ed. Grace of Sun Oil Company, and C. W. Wood of Mason-Neilan, did a swell job.

Questions dealing with all phases of industrial instrumentation were submited and one or more of the group volunteered to answer, followed by members' comments.

The meeting proved so interesting that we intend to make provision for another in the very near future.

The dinner attendance was twenty, and there were 43 at the meeting.

Election of officers for 1944 will be held at our December meeting and all members are requested to attend.

It is with deep regret that we announce the death of one of our members, Mr. Richard T. Turner, Rosetree Road, Media, Pa., on November 27th. Mr. Turner's death was caused by an accident at Sun Oil Company, Marcus Hook, where he had been employed for ten years.

—GEORGE HAMMER, *Secretary*

"IT'S ABOUT TIME"

Substance of speech by R. W. APPLEGATE *to Los Angeles Guild, Horological Association of California, November 17, 1943.*

IT'S about time we paid full recognition to the magnitude of the contribution the Horologist is making to the War Effort. Your contribution is of prime importance—important enough that your priority rating should be AA-1 instead of the AA-5 which has proved so inadequate in providing necessary replacement parts as well as tools to do essential work.

We propose that from this meeting shall come adequate qualification and presentation to the WPB to raise the priority rating of Horologists to one more commensurate with their contribution to the War Effort.

This is no small task; yet we mean to accomplish it, but not without your assistance.

Only to the extent that you feel your profession is dignified can it be lifted to its rightful level.

It's about time this profession shifted into high gear and pulled away from the rut in which it still wallows.

We salute those who have stayed loyally on the jobs in the Horological Association—working for the day of recognition. They have unselfishly given of their time and money.

Gentlemen, let's take the challenge and carry on to a supreme achievement in occupying our place in the War Effort.

You have all heard a great deal about MRO.

I should like to see every one of you displaying in his place of business a certificate: "Graduate and Licensed Horologist in the Art of Maintenance, Repair and Operation of Timing Devices."

In the scale of importance in the War Effort we might list bombers, warships, gunpower, manpower, machinery, electricity and a hundred more—and yet miss the *Vital Spark* in the whole complex scheme.

Technical detail and scientific description are not essential for the lay mind to conceive the all-important role of this *Vital Spark*. There is NO substitute for the *Vital Spark*.

Production, transportation, utilization of production, every broadside from a battleship, every salvo of field-artillery, depend on the *Vital Spark*; the discharge of bomb loads, paratroopers, the synchronization of sound and speed; fuzes on cannon projectiles, and multiplied millions of activities are using the *Vital Spark*.

Every war plane that takes off into the blue symbolizes high American genius—but it requires coördination to construct thousands of bombers, fighters and transports. Huge quantities of material must be converted into finished parts and assembled. These materials and parts must be shipped to numerous destinations. It's the *Vital Spark* functioning properly that makes the deliveries. Not too little—Not too late. Then the *Vital Spark* finally enables our air forces to smite the foe.

There is no effective substitute for the *Vital Spark*. How can we ever adequately describe this *Vital Spark*? It is considerably smaller than a bass drum, light enough for one man to lift it, and it looks a bit complicated though in principle it's a simple device. Shall we keep it a secret? Or must we go on and on, to facilitate your minds to a reasoning point, that *the timing device* is the all-important, super-super vital spark, imposing its preëminence over every activity in the War Effort?

The high responsibility—the solemn seriousness of your duty, as modern chronometrists—that of arranging diminutive precision parts to a complete mechanism for the exact measurement of time—is the highest in the land.

Distinguished service may win a medal—But the timing device you apply your skill upon may serve a man who will be wearing a medal.

Who can say what your contribution has been? And you have made it by the use of the lowest rating, MRO AA5. Are you satisfied with this rating?

Time Marches On! Will we go with it?

It was constant hammering of far-seeing auto dealers on the factory engineers which succeeded in getting a better power plant for your automobile. I believe the Horological Associations of America are capable of causing our timing device manufacturers in America to produce a higher grade device than we now have.

You who labor over the miniature devices used for the measurement of time have done a magnificent job and have qualified yourselves to designate what should be named a timing device or a jewelry item.

Anything smaller than 10 ligne should be a jewelry item—not a dependable timing device. Only those 10 ligne and larger should be approved as dependable timing devices.

I propose that the United Horological Ass'n establish a laboratory for testing every time-piece imported to this country, either as a finished time-piece or to be assembled in the United States, and it shall meet with the standard of requirement in order to be released for sale.

I further propose that all American manufacturers of timing devices coöperate and assist in the establishment of such laboratory; and to agree upon a stamp or seal of approval furnished by the United Horological Ass'n for such time devices as they fulfill standard requirements.

Further—that all American manufacturers submit for test and approval every new model to be manufactured before being offered for sale;

To approve and endorse the United Horological laboratory as criterion on timing devices meeting standard of requirements.

I further propose that in establishing such a laboratory the United Horological Ass'n and the American manufacturers contribute to its establishment and maintenance to the end that the laboratory Seal of Approval shall come to have the same value to a timing device as the word "sterling" does to silver.

You Horologists are important to the American manufacturers of timing devices. Without your service in maintenance and repair, a chaotic condition would exist.

It's necessary that we have a comprehensive program of education and legislation sufficient in scope to attract all who earn a livelihood in chronometry and horography, a double-barrelled instrument elevating to the high rank of importance all who adjust timing devices for accurate measurement of time.

Our sights are trained on the problem, and we expect your whole-hearted coöperation and support to gain the objective—that of placing in its rightful place the manpower involved—among the instrument technicians placing complicated mechanisms in the hands of our fighting forces and in the production plants, for the more efficient accomplishment of production schedules and of military missions.

The future holds amazing promise for our profession if we act now. If ever there was a time when we could present a strong organization of successful horologists it is now—because, you, Gentlemen, are engaged in mass production, maintenance and repair of the Vital Spark device.

So, it's about time we set in motion these proposals and other measures to dignify our profession and take our rightful place.

When the lights come on again, all over the world, may we be able to say—"Mission accomplished. All is well!"

Conductivity Measurements

Concluded from page 731

change in conductivity at the two cells, as measured by means of a stop-watch, provides an accurate measure of the pasteurizing time. Similar applications have been found in measuring the flow of water through pipes and weirs.

Conductivity apparatus is being used to check the operation of hydrogen ion exchange and similar water treating apparatus. It is particularly important to obtain a check of the operation of equipment of this character because of the need for regeneration of the active material after a given volume of water has been treated.

The use of the conductance principle for obtaining the endpoints of many chemical reactions is well known. This method is particularly useful for analysis of colored liquids which interfere with the use of colorimetric methods.

Another one of the early practical applications for conductance measurements has been their use in determining the ash in sugars.[6] In this particular case the conductance depends upon the electrolytic salts present in the sugar ash since sugar itself is a non-electrolyte. This particular application illustrates the possibility of determining the concentration of a non-electrolytic material if it is accompanied by a definite percentage of electrolytic material.

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[3]U. S. Patent No. 2,263,932.

[4]"The Digby & Biggs Dionic Water Tester," Evershed Catalog, 1911.

[5]Zerban & Sattler, *Facts About Sugar*, Dec., 1926.

[6]Rogers-Borden Co. Research Lab. memorandum, 1941.

Recent WPB Orders Pertaining to Instruments

No.	Subject	Page
L-134	Instruments, Valves, and Regulators Used in Industrial Processes	747
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NOTE—All orders are signed "WAR PRODUCTION BOARD, By JOSEPH WHELAN, *Recording Secretary.*"

PREVIOUSLY PUBLISHED IN *INSTRUMENTS*

ARTICLES on GOV'T ACTIONS: H. P. Rockwell, "Substitutes for Strategic and Critical Materials," **Nov. 1942.** M. F. Behar, "First Comprehensive Standard on Electrical Instruments is Promulgated," WPB release: "Precision Measuring Instruments for Individuals," **April 1943.** H. P. Rockwell, "Instrument Men Represented in WPB," **May 1943.** E. A. Capelle. "WPB Regulations Pertaining to Industrial Regulations," F. A. Watts, Petroleum Industry Priority Regulations," Lloyd A. Worden, "APB Standardization," **Sept. 1943.**

ORDERS: L-203 Electrical Indicating Instruments (and 4-page Form 1682) **July 1943.** E-5-a Gages and Precision Measuring Hand Tools; E-5-a Interpretation; E-9 Precision Measuring Instruments and Testing Machines; L-58 Sextants; L-58 Interpretation; L-134 Instruments, Valves, and Regulators Used in Industrial Processes; L-144 Laboratory Equipment; L-144 Interpretation; L-151 Domestic Watthour Meters; L-154 Power, Steam and Water Auxiliary Equipment; L-154 Schedule I; L-154 Amendment I to Schedule I—Water Meters; L-154 Schedule VI; L-175 Railroad Standard Watches; L-183-a Electronic Equipment; L-190 Scales, Balances and Weights; L-203 Electrical Indicating Instruments Interpretation; L-206 X-Ray Equipment; L-206 Interpretation; L-234 Industrial Type Instruments; L-252 Valves and Valve Parts; L-264 Rectifier Tubes; L-265 Electronic Equipment; L-270 Material Entering Into Production of Maintenance Equipment for Automobiles, Trucks, etc.; L-272 Industrial Type Instruments, Control Valves and Regulators: Simplification including Schedules I to V; L-272 Interpretation; L-272 Schedule VI; M-50 Jewel Bearings; P-43 Laboratories; P-133 Electrical Equipment, **Sept. 1943.**

L-134

NOV. 17, 1943

[As Amended]

PART 3289—RADIO AND RADAR [1]

INSTRUMENTS, VALVES, AND REGULATORS USED IN INDUSTRIAL PROCESSES

The fulfillment of requirements for the defense of the United States has created a shortage in the supply of chromium and nickel for defense, for private account and for export; and the following order is deemed necessary and appropriate in the public interest and to promote the national defense.

§ 3289.6 [1] *Conservation Order L–134*—(a) *Definitions.* For the purposes of this order:

(1) "Person" means any individual, partnership, association, business trust, corporation, governmental corporation or agency, or any organized group of persons whether incorporated or not.

(2) "Manufacturer" means any person manufacturing any industrial instrument, instrument end, instrument connection, control valve, or regulator as defined below, to the extent he is engaged in such manufacture; and includes sales and distribution outlets controlled by such manufacturer.

(3) "Dealer" means any person primarily engaged in the business of selling or distributing industrial instruments, control valves, or regulators, whether at wholesale, retail, or otherwise, but does not include sales and distribution outlets controlled by a manufacturer.

(4) "Industrial instrument" means any type of indicating, recording or measuring, or controlling instrument ordinarily used in industrial processes and containing an instrument connection listed in subparagraph (5) below, or an instrument end listed in subparagraph (6) below; except "laboratory equipment" as defined in Order L–144.

(5) "Instrument connection" means any of the following, to the extent used with or in an industrial instrument, if fabricated in whole or in part from nickel, chromium, or any alloy thereof: capillary tubing having an internal diameter of .025" or less; protective armor tubing; tubes or springs (pressure measuring systems); diaphragms or bellows (pressure measuring systems except differential measuring systems) and extension lead wire.

(6) "Instrument end" means any of the following to the extent used with or in an industrial instrument, if fabricated in whole or in part from nickel, chromium, or any alloy thereof; sockets, wells, protecting tubes, sheaths and target tubes; liquid level floats, float rods, float cages and flanges, expansion and immersion tubes; venturi tubes; cleanout valve trim and liner for use with venturi tubes; flow nozzles; orifice plates; orifice meter accessories; thermocouples and thermocouple wire; temperature bulbs (fluid filled tube system type); bushings and revolving or coupling nuts; safety shutters and switches for radiation pyrometers; contact rods for flame control; straightening vanes; studs for differential pressure chambers; conductivity cells for measuring conductivity of fluids; pitot tubes; and flexible and rigid extension stems for temperature bulbs.

(7) "Control valve" means any glove or butterfly type valve, the inner portion of which is automatically positioned by pneumatic, hydraulic, or electric motive power, containing any of the parts listed in paragraphs (d) (1), (2), (3) and (5) provided such parts are fabricated in whole or in part from nickel or chromium, or any alloy thereof. The term shall not include any type of gate valve or slide valve.

(8) "Regulator" means any self-operated or integral pilot operated type valve used to control temperature, pressure above 25 p. s. i., pressure where inlet pressure is above 25 p. s. i. flow or liquid level, and containing any of the parts listed in paragraphs (d) (1), (2), (3), and (5), provided such parts are fabricated in whole or in part from nickel or chromium, or any alloy thereof.

(9) [Revoked January 30, 1943.]

(b) *General restrictions.* (1) On and after September 9, 1942, no manufacturer shall knowingly put in process any chromium, nickel, or alloy thereof, in the production of any instrument end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator, except for use under such operating conditions, if any, as may be specified in paragraphs (c) or (d): *Provided, however,* That the provisions of this subparagraph shall not apply to such items sold to another manufacturer or dealer for resale, or to items sold for use in a foreign country (except Canada)

(2) On and after September 9, 1942, no manufacturer or dealer shall knowingly deliver, and no person shall accept delivery of, any instrument end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator, except for use under such operating conditions, if any, as may be specified in paragraph (c) or (d): *Provided, however,* That the provisions of this subparagraph shall not apply to deliveries by a manufacturer to another manufacturer or dealer for resale, or to deliveries of any item to be used in a foreign country (except Canada).

(3) On and after September 9, 1942, no manufacturer shall put in process any chromium, nickel, or alloy thereof for the production of any instrument end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator except in accordance with the specifications enumerated in paragraph (c) or (d).

(4) On and after September 9, 1942, no manufacturer or dealer shall accept an order for, or deliver, and no person shall accept delivery of any instrument end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator, except pursuant to a preference rating of A–1–c or better: *Provided, however,* That the limitations and restrictions of this paragraph (b) (4) shall not apply to:

(i) Any order accepted by a manufacturer or dealer prior to September 9, 1942, and bearing a preference rating of A–10 or better, or

(ii) Any order for maintenance and repair purposes, bearing a preference rating of A–8 or better, or

(iii) Any order by and for the use of the Army, Navy, Maritime Commission, War Shipping Administration, the Panama Canal, the Coast and Geodetic Survey, the Coast Guard, the Civil Aeronautics Authority, the National Advisory Committee for Aeronautics, or the Office of Scientific Research and Development.

(5) No person shall accept delivery of any instrument end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator for use, unless based upon experience records he expects to install the item which is being delivered, and all similar items on hand, within the next 90 days.

(6) *Certification to be furnished.* (i) Each person (other than a manufacturer or dealer acquiring the item for resale or any person purchasing the item for use in a foreign country, except Canada) receiving delivery of an instrument

[1] Formerly Part 1224, § 1224.1.

end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator, shall certify to the manufacturer or dealer from whom he receives such delivery, as a condition to receiving delivery, the following on the purchase order, or in a separate letter:

The undersigned hereby certifies that

(here fill in items ordered)

will be used under the operating conditions permitted for such items under the terms of Conservation Order L-134. The operating conditions under which the items will be used are:

Here fill in operating conditions, if any (by reference to paragraph of order) for which items will be used

---------- Company

By ----------

Provided, however, That such certification shall be required only where a limitation on the use of the item in question is prescribed in an operating condition specified in paragraph (c) or (d), except where otherwise provided in paragraph (c) or (d).

(ii) No person shall make a delivery under this paragraph (b) who has reason to believe that the person accepting delivery has furnished a false certification; and no person shall falsely furnish the certification specified above. The certification specified above shall constitute a representation to the War Production Board, of the facts certified therein.

(7) Nothing in this order shall be construed to place any restriction upon any instrument, valve or regulator, or part thereof, unless such instrument, valve, regulator or part thereof contains nickel, chromium, or any alloy thereof (not including plating); or upon any instrument, valve regulator or part thereof which was manufactured prior to May 26, 1942.

(8) The provisions of this order shall not apply to any instrument end, instrument connection, industrial instrument containing an instrument end or instrument connection, control valve, or regulator to be incorporated in, or used exclusively on board a vessel of the Army or Navy of the United States.

(c) *Operating conditions and specifications for instrument ends, instrument connections, and industrial instruments containing instrument ends or connections.* Pursuant to the provisions of paragraph (b) hereof, the production and delivery of the following instrument ends, instrument connections, and industrial instruments containing instrument ends or instrument connections shall be governed by the following operating conditions and specifications:

(1) *Capillary tubing having an internal diameter of .025" or less*—(i) *Operating conditions.* Capillary tubing having an internal diameter of .025" or less shall be delivered for use only under the operating conditions specified in List A paragraph 1; capillary tubing for use with a mercury filled thermal system may be delivered for use under any operating condition.

(ii) *Specifications.* Capillary tubing having an internal diameter of .025" or less shall be manufactured from a metal whose nickel and chromium alloy content does not exceed that of Type 347 metal and shall be manufactured in the following four sizes only: .06" x .007"; .06" x .011" .06 x .017"; .06" x .025".

(2) *Protective armor tubing*—(i) *Operating conditions.* Protective armor tubing shall be delivered for use only under the operating conditions specified in List A, paragraph 1.

(ii) *Specifications.* Protective armor tubing shall be manufactured in lengths not in excess of 6" at either the instrument or bulb.

(3) *Tubes and springs (Pressure measuring systems)*—(i) *Operating conditions.* Tubes or springs for pressure measuring systems may be delivered for any use, but certification of operating conditions shall be required where delivery is for the use described in List A, paragraphs 1 or 2.

(ii) *Specifications.* The total nickel and chromium alloy content of such tubes or springs shall not exceed 6% chromium (with no nickel): *Provided, however,* That for use under the operating conditions described in List A, paragraphs 1 or 2, the total nickel and chromium alloy content shall not exceed 32%.

(4) *Diaphragms or bellows, (Pressure measuring systems except differential measuring systems)—Operating conditions.* Diaphragms or bellows for pressure measuring systems (except differential measuring systems) shall be delivered for use only under the operating conditions specified in List A, paragraphs 1 or 2.

(5) *Sockets, wells, protecting tubes, sheaths and target tubes.* The operating temperatures specified below shall be deemed part of the operating conditions for purposes of certification:

(i) *Operating temperature up to 1,400° F*—(a) *Operating conditions.* When used under operating temperatures up to 1,400° F., sockets, wells, protecting tubes, sheaths and target tubes shall be delivered for use only under the operating conditions specified in List A, paragraphs 1 (a) to 1 (k) inclusive, paragraph 2, or paragraph 3 (b) or 3 (c), or on aircraft.

(b) *Specifications.* The total nickel and chromium alloy content of sockets, wells, protecting tubes, sheaths and target tubes shall not exceed 30%, or 20% of either nickel or chromium: *Provided, however,* That for use under operating conditions specified in List A, paragraph 1 (f) or 1 (k) the total nickel and chromium alloy content shall not exceed 80%, and maximum nickel and chromium content of not over 65% and 30%, respectively.

(ii) *Operating temperatures from 1,401° F. to 1,900° F.—Specifications.* The total nickel and chromium alloy content of sockets, wells, protecting tubes, sheaths and target tubes, used under operating temperatures from 1,401° F. to 1,900° F. shall not exceed 52%, and the nickel and chromium contents shall not exceed 35% and 28%, respectively: *Provided, however,* That for use under the operating conditions specified in List A, paragraphs 1 (f) or 1 (k) the total nickel and chromium alloy content shall not exceed 80%, and maximum nickel and chromium content of not over 65% and 30%, respectively.

(iii) *Operating temperatures of 1,901° F. and above*—(a) *Operating conditions.* When used under operating temperatures of 1,901° F. and above, sockets, wells, protecting tubes and sheaths shall only be delivered for use under the operating conditions specified in List A, paragraphs 1 (f) or 1 (k). Target tubes may be delivered for use under any conditions.

(b) *Specifications.* Sockets, wells, protecting tubes, sheaths and target tubes employed under the operating conditions specified in (a) above shall contain a maximum total nickel and chromium alloy content not to exceed 80%, and maximum nickel and chromium content of not over 65% and 30%, respectively.

(6) *Temperature bulbs (fluid filled tube system type)*—(i) *Operating conditions.* When used without sockets or protecting tubes, temperature bulbs (fluid filled tube system type) may be delivered for use only under the operating conditions specified in List A, paragraphs 1, 2, 3 (b) or 3 (c)

(ii) *Specifications.* The total nickel and chromium alloy content of temperature bulbs (fluid filled tube system type) shall not exceed 30%, or 20% of either nickel or chromium. No nickel, chromium, or alloy thereof, shall be used in temperature bulbs (except for mercury filled systems) when such bulbs are used in a socket or in protecting tubes. When used with a mercury filled system in a socket, temperature bulbs shall be manufactured from S. A. E. 4140 or alternate steels of no greater chromium alloy content and containing no more than 0.60% nickel.

(7) *Bushings and revolving or coupling nuts—Operating conditions.* Bushings and revolving or coupling nuts shall be delivered for use only under the operating conditions specified in List A, paragraphs 1 or 2.

(8) *Flexible and rigid extension stems for temperature bulbs*—(i) *Operating conditions.* When used with temperature bulbs without separable sockets or protecting tubes, flexible or rigid extension stems shall be delivered for use only under the operating conditions specified in List A, paragraph 1, 2, 3 (b) or 3 (c).

(ii) *Specifications.* The total nickel and chromium alloy content of such stems shall not exceed 30%, or 20% of either nickel or chromium.

(9) *Contact rods for flame control—Specifications.* The alloy content of contact rods for flame control, including contiguous brackets or clamps, shall not exceed 80% nickel and 20% chromium.

(10) *Thermocouples.* The operating temperatures specified below shall be deemed part of the operating conditions for purposes of certification.

(i) *Operating temperatures up to 800° F.—Specifications.* Where used in temperature ranges up to and including 800° F., the thermocouple wire alloy content shall not exceed 46% nickel, and the size of the wire shall not exceed #14 B and S gage.

(ii) *Operating temperatures from 801° F. to 1,400° F.—Specifications.* Where used in temperature ranges between 801° F. and 1,400° F., inclusive, the thermocouple wire alloy content shall not exceed 46% nickel, and the size of the wire shall not exceed #8 B and S gage, or as an alternate, the thermocouple wire alloy content shall not exceed 95% nickel or 20% chromium in either wire, and the size of the wire shall not exceed #14 B and S gage.

(iii) *Operating temperatures from 1,401° F. to 2,050° F.—Specifications.* Where used in temperature ranges between 1,401° F. and 2,050° F., inclusive, the thermocouple wire chromium alloy

content shall not exceed 20% chromium in either wire, and the size of the wire shall not exceed #8 B and S gage.

(iv) *Operating temperatures of 2,051° F. and above—(a) Operating conditions.* When used in temperature ranges of 2,051° F. and above, thermocouple wire shall be delivered for use only under the operating conditions specified in List A, paragraphs 1 (f) or 1 (k).

(b) Specifications. The size of the wire shall be limited to No. 2 B and S gage or smaller when used under the operating conditions in List A, paragraph 1 (f), and shall be limited to No. 8 B and S gage or smaller when used under the operating conditions of List A, paragraph 1 (k).

(v) *Special provisions for replacement.* Except with respect to size of extension lead wire when used with potentiometer type pyrometers, the limitations of subparagraphs (i), (ii), (iii) and (iv) shall not apply to replacements if the extension lead wire or parts required to recalibrate existing instruments are not available in the user's plant.

(11) *Extension lead wire—specifications.* The size of the wire, except for wire used on aircraft or for superheater pyrometers on locomotives, shall be limited to #14 B and S gauge, or smaller.

(12) *Safety shutters and switches for radiation pyrometers — Specifications.* The nickel or chromium alloy content of safety shutters for radiation pyrometers shall not exceed 20% each; except that this restriction does not apply to the nickel or chromium alloy content of switches for radiation pyrometers.

(13) *Liquid level float cages and flanges*—(i) *Operating conditions.* Liquid level float cages and flanges shall be delivered for use only under the operating conditions specified in List A, paragraphs 2 (a) and 3 (b).

(ii) *Specifications.* The total nickel and chromium alloy content shall not exceed 30%, or 20% of either nickel or chromium: *Provided, however,* That when used under the operating conditions of List A, paragraph 2 (a), the nickel and chromium alloy content shall not exceed that of the contiguous metal.

(14) *Liquid level floats and float rods*—(i) *Operating conditions.* Liquid level floats and float rods shall be delivered for use only under the operating conditions specified in List A, paragraphs 1, 2, or 3 (b).

(ii) *Specifications.* The total nickel and chromium alloy content shall not exceed 30%, or 20% of either nickel or chromium: *Provided, however,* That when used under the operating conditions of List A, paragraph 2 (a), the nickel or chromium alloy content shall not exceed that of the contiguous metal.

(15) *Liquid level expansion and immersion tubes—Operating conditions.* Liquid level expansion and immersion tubes shall be delivered for use only under the operating conditions specified in List A paragraphs 1 or 2 or at temperatures of 400° F. and above.

(16) *Flow nozzles—Operating conditions.* Flow nozzles shall be delivered for use only in the presence of a flowing medium with a temperature in excess of 900° F.

(17) *Pitot tubes—Specifications.* No nickel, chromium or alloy thereof shall be used in the manufacture of pitot tubes, except when used on aircraft.

(18) *Orifice plates—Operating conditions.* Orifice plates shall be delivered for use only under the operating conditions specified in List A, paragraphs 1, 2, 3 (b) or 3 (c).

(19) *Orifice meter accessories—Specifications.* No nickel, chromium or alloy thereof shall be used in the manufacture of settling chambers, separating chambers or condensers.

(20) *Straightening vanes*—(i) *Operating conditions.* Straightening vanes shall be delivered for use only under the operating conditions specified in List A, paragraphs 1 or 3 (c) and their delivery shall be further limited to use in pipes having an internal diameter of 10 inches or less.

(ii) *Specifications.* The total nickel and chromium alloy contents shall not exceed 30%, or 20% of either nickel or chromium.

(21) *Cleanout valve trim and liners for use with Venturi tubes—Operating conditions.* Cleanout valve trim and liners for Venturi tubes shall be delivered for use only under the operating conditions specified in List A, paragraphs 1, 2, 3 (b) or 3 (c).

(22) *Venturi tubes — Specifications.* No nickel, chromium or alloy thereof shall be used in the manufacture of Venturi tubes.

(23) *Studs for differential pressure chambers—Specifications.* Studs for differential pressure chambers shall be manufactured from S. A. E. 4140 or alternate steels of no greater chromium alloy content and containing no more than 0.60% nickel.

(24) *Conductivity cells for measuring conductivity of fluids—Operating conditions.* Conductivity cells for measuring conductivity of fluids shall be delivered for use only under the operating conditions specified in List A, paragraphs 1 or 2.

(d) *Operating conditions and specifications for control valves and regulators.* Pursuant to the provisions of paragraph (b) hereof, the production and delivery of the following control valves and regulators shall be governed by the following operating conditions and specifications:

(1) *Bodies, bonnets and blind flanges*—(i) *Operating conditions.* Bodies, bonnets and blind flanges shall be delivered for use only under the operating conditions specified in List A, paragraph 2 (a) and 3 (b).

(ii) *Specifications.* When used under operating conditions of List A, paragraph 3 (b) the total nickel and chromium alloy content shall not exceed 30%, or 20% of either nickel or chromium: *Provided, however,* That when used under the operating conditions of List A, paragraph 2 (a), the nickel and chromium alloy content shall not exceed that of the contiguous metal.

(2) *Inner valves and seat rings*—(i) *Operating conditions.* Inner valves and seat rings shall be delivered for use only under an operating pressure drop of 50 p. s. i. or more, or under the operating conditions specified in List A, paragraphs 1 or 2.

(ii) *Specifications.* When used under operating conditions of a pressure drop of 50 p. s. i. or more, the flow cutting surface shall be made of carbon steel, faced, where practicable, with a chromium or nickel alloy not in excess of 3/32" finished thickness. When used under the operating conditions specified in List A, paragraphs 1 or 2, the total nickel and chromium alloy content shall not exceed 30%, or 20% of either nickel or chromium: *Provided, however,* That when used under the conditions of List A paragraph 2 (a) the nickel and chromium alloy content shall not exceed that of the contiguous metal.

(3) *Studs for valve bodies and flanges*—(i) *Operating conditions.* Studs for valve bodies and flanges may be used under any operating conditions; but certification shall be required for use under the operating conditions of List A, paragraph 3 (b) or 3 (d).

(ii) *Specifications.* Studs for valve bodies and flanges shall be manufactured from S. A. E. 4140 or alternate steels of no greater chromium alloy content and containing no more than 0.60% nickel: *Provided, however,* That where used under the operating conditions specified in List A, paragraphs 3 (b) or 3 (d) the total nickel and chromium alloy content shall not exceed 30%, or 20% of either nickel or chromium.

(4) [Revoked January 30, 1943.]

(5) *Stems, bushings and guiding surfaces for control valves, and regulators—Specifications.* The total nickel and chromium alloy content of stems, bushings, and guiding surfaces for control valves and regulators shall not exceed 30%, or 20% of either nickel or chromium.

(e) *Ninety-day exemption of Army, Navy, and Maritime Commission.* The provisions of this order shall not apply to deliveries to and for the use of the Army, Navy, or Maritime Commission until August 26, 1942. As used in this paragraph, the terms "Army," "Navy," and "Maritime Commission" shall not include any privately operated plant or shipyard, financed or controlled by any of these organizations, or operated on a cost-plus-fixed-fee basis.

(f) *Appeals.* Any person affected by this order who considers that compliance therewith would work an exceptional and unreasonable hardship upon him may appeal to the War Production Board setting forth the pertinent facts and the reasons he considers he is entitled to relief. The War Production Board may thereupon take such action as it deems appropriate.

(g) *Reports and letters concerning this order.* All reports required to be filed by this order, and all letters and inquiries concerning this order, shall be addressed to War Production Board, Radio and Radar Division, Washington, D. C., Ref: L-134.

(h) *Violations.* Any person who wilfully violates any provision of this order, or who wilfully furnishes false information to the War Production Board in connection with this order is guilty of a crime and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using material under priority control and may be deprived of priorities assistance by the War Production Board.

(i) *Records and reports.* All manufacturers affected by this order shall keep and preserve for not less than two years accurate and complete records

concerning production, deliveries, and orders for industrial instruments.

All persons affected by this order shall execute and file with the War Production Board, such reports and questionnaires as said Board shall from time to time request.

Issued this 17th day of November 1943.

LIST A

PARAGRAPH 1. When exposed to:
(a) Nitric acid (dilute or concentrated)
(b) Coke oven gas.
(c) Blast furnace gas.
(d) Sulphurous gases.
(e) Steam above 200 p. s. i. or 400° F.
(f) Molten metal baths.
(g) Sulphuric or hydrochloric acids.
(h) Sour gas and vapors, and liquids contaminated with sour gas and vapors.
(i) Hydrofluoric acid.
(j) Salt brine in crude petroleum.
(k) Salt baths containing nitrates, chlorides, cyanides, or fluorides.

PAR. 2. (a) When contiguous metal coming in contact with the processed medium at the point of measurement or control is also a nickel or chromium alloy.

(b) When contiguous surfaces coming in contact with the processed medium at the point of measurement or control are nonmetallic but no protection other than that containing nickel or chromium will withstand the corrosive medium.

(c) In the production of synthetic rubber, when an explosive hazard due to chemical reaction cannot otherwise be avoided, or where acetic acid has a corrosive effect on seating, guiding, and measuring surfaces.

(d) When no other material can be substituted without contaminating the material being processed.

PAR. 3. When the fluid to which the part is to be subject is under:

(a) Static pressure of 250 pounds per square inch or more;

(b) Temperature of 750° F. and above, or minus 20° F. and below;

(c) Normal pipe velocity of 5,000 ft. per minute or more for gases or vapors; or 300 ft. per minute or more for liquids;

(d) Temperature of minus 250° F. to minus 20° F. inclusive, and from 400° F. to 1,250° F. inclusive, and 400 p. s. i. to 2,500 p. s. i. inclusive.

L-144

OCT. 9, 1943

Corrected Copy 2

PART 3296—SAFETY AND TECHNICAL EQUIPMENT[1]

LABORATORY EQUIPMENT

§ 3296.56[1] *General Limitation Order L–144*—(a) *Definitions.* For the purposes of this order:

(1) "Laboratory equipment" means any apparatus, instrument, appliance, device, equipment, or part thereof, designed primarily for use in laboratories. However, the restrictions of this order cover only those items of laboratory equipment which are included on List A, attached hereto. (The language at the top of List A should be examined closely to determine what items are included on List A.)

(2) "Distributor" means any person located in the United States, its territories or possessions, or the Dominion of Canada, who purchases laboratory equipment for the purpose of resale.

(3) [Deleted Oct. 9, 1943]

(b) *Restrictions on the sale and delivery of laboratory equipment.* No person shall sell or deliver any item of laboratory equipment included on List A of this order to any person, other than a distributor, except to fill a purchase order or contract specifically authorized by the War Production Board on Form WPB–1414 (formerly Form PD–620).

(c) *Restrictions on purchase of laboratory equipment.* No person shall purchase or accept delivery of any laboratory equipment, if he knows or has reason to believe that the sale or delivery of such laboratory equipment is prohibited by the terms of paragraph (b) of this order.

(d) *Authorizations on Form WPB–1414 and extensions of such authorizations.* (1) Each person seeking authorization, pursuant to paragraph (b) of this order, to receive laboratory equipment shall prepare Form WPB–1414 in the manner prescribed therein and shall file such form with the War Production Board, Washington, D. C., Ref: L–144. (Copies of Form WPB–1414 may be obtained at the local offices of the War Production Board.)

(2) Any person receiving specific authorization on Form WPB–1414 shall notify his supplier of such authorization by furnishing him with a certification in substantially the following form (on the purchase order or contract, or on an attached document):

The undersigned hereby certifies that he has been specifically authorized by the War Production Board on Form WPB–1414, Case No. ------, to receive the laboratory equipment ordered by the within (or attached) purchase order or contract, in accordance with the provisions of Limitation Order L–144.

Name----------
By----------
Authorized official
Date----------

Any such certification shall be signed by an authorized official, either manually or as provided in Priorities Regulation 7, and shall constitute a representation to the supplier and to the War Production Board of the facts certified therein. The supplier may rely upon such representation, unless he knows or has reason to believe such representation to be false.

(e) *Assignment of preference ratings on Form WPB–1414.* In conjunction with the granting of specific authorizations to receive laboratory equipment on Form WPB–1414 pursuant to paragraph (b) of this order, the War Production Board may also assign preference ratings to the authorized deliveries on such form. Any preference rating so assigned shall be applied and extended only in accordance with the terms of Priorities Regulation 3.

(f) *Records.* All persons affected by this order shall keep and preserve for not less than two years accurate and complete records of all sales, deliveries and purchases of laboratory equipment.

(g) *Applicability of regulations.* This order and all transactions affected thereby are subject to all applicable regulations of the War Production Board, as amended from time to time.

(h) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(i) *Violations and false statements.* Any person who wilfully violates any provision of this order, or who, in connection with this order, wilfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing or using, material under priority control and may be deprived of priorities assistance.

(j) *Communications with the War Production Board.* All communications concerning this order shall, unless otherwise directed, be addressed to the War Production Board, Safety and Technical Equipment Division, Washington, D. C., Ref: L–144.

The above paragraph (a) (2) supersedes Interpretation 1 of the order, issued July 17, 1943.

Issued this 9th day of October 1943.

LIST A

The sale and delivery of items included on List A are subject to the restrictions set forth in paragraph (b) of this order. List A includes only those items coming within the classifications set forth below which have a value, individually, of $50 or more. Any item coming within the classifications set forth below which has a value, individually, of less than $50 shall not be regarded as being included on List A. Secondhand equipment is not included, nor are parts and materials needed to repair or maintain existing equipment. Furthermore, accessories and attachments for List A items are not included when sold separately. (It should also be understood that no item is included on List A unless it is designed primarily for use in laboratories. For example, a centrifuge which is designed to separate cream from milk is not designed primarily for use in laboratories and therefore is not included on List A.)

Analytical balances (sensitivity 1/5 mg. or more sensitive)
Calorimeters
Centrifuges
Hydrogen ion meters (electrometric)
Metalloscopes
Microscopes (except Brinnell and Tool Makers)
Microtomes
Potentiometers, Wheatstone Bridges and Resistance Boxes
Refractometers
Spectrographs, spectroscopes, spectrometers and spectrophotometers
Vacuum pumps (1 micron or higher vacuum)

INTERPRETATION 1

[Superseded October 9, 1943.]

[1] Formerly Part 1261, § 1261.1.

L-203

October 23, 1943
[As Amended]

PART 3087—ELECTRICAL INDICATING INSTRUMENTS

The fulfillment of requirements for the defense of the United States has created a shortage in the production of electrical indicating instruments for defense, for private account and for export, and the following order is deemed necessary and appropriate in the public interest and to promote the national defense:

§ 3087.1 *General Limitation Order L-203*—(a) *Definitions.* For the purpose of this order:

(1) "Person" means any individual, partnership, association, business trust, corporation, governmental corporation or agency, or any organized group of individuals whether incorporated or not.

(2) "Manufacturer" means any person engaged in the production, assembly or fabrication of electrical indicating instruments.

(3) "Electrical indicating instrument" ("meter") means a measuring mechanism the pointer of which responds to a change in an electrical quantity. The term shall include instrument mechanisms and instrument relays made therefrom; also, small panel, switchboard, portable, and aircraft electrical instruments. The term shall not include:

(i) Any multi-purpose portable instrument capable of measuring more than one electrical quantity and embraced within the classification of electronic test equipment in General Scheduling Order M-293;

(ii) Any instrument made with metal bearings and normally used in automotive vehicles or mobile construction machinery;

(iii) Any electrical aircraft self-synchronous indicator or transmitter.

(4) "Approved order" means any order which is embraced within any one of the following categories: *Provided*, That no order shall be brought within the provisions of subparagraphs (i), (ii) or (iv) of this paragraph (a) (4) by the subdivision thereof or by any subdivision of requirements:

(i) Any order for less than 500 identical electrical indicating instruments which conform to the ranges and dimensions established and prescribed for "Electrical indicating instruments" by American War Standard C39.2—1943, as approved January 8, 1943, and published by American Standards Association;

(ii) Any order for less than 500 identical electrical indicating instruments of flange diameter, height, or width exceeding 3½";

(iii) Any order for polarized vane non-jewelled instruments;

(iv) Any order for less than 500 identical electrical indicating instruments which conform to approved United States Army or Navy specifications specified on the order;

(v) Any order authorized by the War Production Board on Form WPB-1682 in the manner provided in General Scheduling Order M-293.

(b) *Restrictions on acceptance and filling of orders.* Any person who places, accepts or fills an order authorized on Form WPB-1682, in the manner provided in General Scheduling Order M-293, shall comply with such restrictions and conditions as are specified on the form.

(c) *Production equipment.* No manufacturer shall produce, or cause to be produced, fabricated or assembled, any tools, jigs, dies or other production machinery or equipment designed for the manufacture or production of electrical indicating instruments of types, ranges, sizes and specifications not embraced within the categories of approved orders defined in paragraphs (a) (4) (i) or (a) (4) (iv) hereof: *Provided, however*, That the provisions of this paragraph shall not apply to the maintenance, repair, replacement or improvement of existing tools, dies, jigs, and other production machinery equipment. The provisions of this paragraph shall not apply with respect to the manufacture of polarized vane non-jewelled instruments or instruments of flange diameter, height or width exceeding 3½".

(d) *Scheduling.* On or before the fifteenth day of each calendar month every manufacturer shall file with the War Production Board his proposed delivery schedule for electrical indicating instruments for the following month, and such other information as is required thereby on Form WPB-1685. The delivery schedule for the calendar month following the filing shall be deemed to be approved by the War Production Board upon receipt thereof, unless and until the War Production Board shall otherwise direct, and shall be deemed a frozen schedule within the meaning of Priorities Regulation 18. No manufacturer shall alter any such approved delivery schedule except pursuant to a written direction of the War Production Board which identifies the frozen schedule and states on its face that it is an amendment of that schedule.

(e) *Special directions and exemptions.* (1) The War Production Board may from time to time issue in writing in respect to electrical indicating instruments special orders or directions which:

(i) Alter or freeze delivery or production schedules, in whole or in part;

(ii) Direct the cancellation of any order held by any manufacturer;

(iii) Allocate any unfilled order from one manufacturer to another manufacturer;

(iv) Direct the delivery of any electrical indicating instrument in production or completed to any person at the established price and terms;

(v) Authorize exception or departure from any of the provisions of paragraph (c) hereof; or

(vi) Take such other action as it deems necessary with respect to the placing of orders for, or the production or delivery of electrical indicating instruments or any component parts thereof.

(2) The provisions of this order, other than the provisions of paragraph (e) (1), shall in no event be construed to apply to the maintenance or repair of electrical indicating instruments, nor to purchase orders for component parts of electrical indicating instruments required for the maintenance or repair thereof.

(f) *Applicability of regulations.* This order and all transactions affected thereby are subject to the provisions of all regulations of the War Production Board, except that to the extent of any conflict or inconsistency therewith the provisions hereof shall control.

(g) *Violations.* Any person who wilfully violates any provision of this order, or who, in connection with this order wilfully conceals a material fact or furnishes false information to any department or agency of the United States is guilty of a crime and upon conviction may be punished by fine or imprisonment. In addition any such person may be prohibited from making or obtaining further deliveries of, or from processing or using materials under priorities control and may be deprived of priorities assistance.

(h) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provision appealed from and stating fully the grounds of the appeal.

(i) *Communications.* All reports to be filed, appeals and other communications concerning this order should be addressed to War Production Board, Radio and Radar Division, Washington, D. C. Ref: L-203.

Issued this 23d day of October 1943.

INTERPRETATION

Paragraph (a) (4) (iv) of Limitation Order L-203 defines an "approved order" as including: "Any order for less than 500 identical electrical indicating instruments which conform to approved United States Army or Navy specifications specified on the order" This means specified by the Army or Navy This may occur on direct Army or Navy procurements, or in respect to pu chase orders for instruments which are ultimately for the account of the Army or Navy—e. g., instruments to be installed as components in an end product being manufactured under an Army or Navy prime contract which requires that instruments going into that end product conform to Army or Navy specifications.

The end use of the instruments must be for the account of the Army or Navy. The provision does not mean, therefore, that any person may make any purchase order an "approved order" merely by specifying Army or Navy specifications thereon. The provision applies only to purchase orders placed by or for the ultimate account of the Army or Navy, where the Army or Navy has prescribed the specification in the first instance. (Issued July 10, 1943.)

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L-272

NOTE—Limitation Order L-272 with Schedules I, II, III, IV, V and VI and Interpretation I, were reproduced on pages 550, 551 and 552 of the September *Instruments*. Schedule IV as recently revised, and Schedule VII as recently issued, are reproduced below.

PART 3207—INDUSTRIAL TYPE INSTRUMENTS, CONTROL VALVES AND REGULATORS SIMPLIFICATION

[Schedule IV as Amended November 11, 1943, to Limitation Order L-272]

INDICATING DIAL PRESSURE GAUGES

Section 3207.5 *Schedule IV to Limitation Order L-272* is amended to read as follows:

(a) *Definition.* A "gauge" is any instrument which measures and indicates, but does not record, any pressure or vacuum (regardless of the units specified on the dial) by means of a bourdon spring or springs, a diaphragm, or a bellows; or is any complete element assembly of such an instrument without a case. The following items are excluded, however, and are not gauges subject to this order:

(1) Airborne gauges.

(2) Any pressure regulator which consists of an enclosure containing a bourdon tube and a relay used for the control of an electric motor starter.

(3) Gauges for absolute pressure measurement which are compensated for barometric pressure changes.

(4) Liquid level gauges using diaphragm boxes or equivalent devices as primary elements, and suitable for level measurement in either open or closed containers or both.

(5) Automotive type gauges with dial diameter of three inches or less, either panel or engine mounted, which are used to indicate either oil or air pressure as they may be related to the operation of internal combustion engines, or to the air brake systems on construction machinery, passenger, industrial or farm vehicles.

(6) Gauges of a dial diameter of twelve inches or larger, having an accuracy of ¼ of 1% or better.

(7) Gauges sold as indicating controllers in cases which are normally used to house recording or pneumatic control instruments. If the manufacturer of these gauges buys the gauge elements from a dial pressure gauge manufacturer, however, the pressure ranges must conform to those prescribed in paragraph (b) (2) of this schedule.

(8) Draft gauges which are sold as such.

(b) *Specifications.* (1) Gauges shall be manufactured only in the following sizes (expressed in inches-dial diameter for round dials and inches-horizontal width for square or rectangular dials): 1½, 2, 2½, 3½, 4½, 6, 8½, 12. This restriction on sizes does not apply, however, to the following gauges:

(i) Inspectors test gauges in the 3-inch size.

(ii) Submarine gauges and testing machine gauges in the 16-inch size.

(iii) Railroad gauges in the 5-inch and 6¾-inch sizes.

(iv) Special gauges for specific Navy applications, the manufacture of which may be authorized in writing by the War Production Board.

(2) Gauges shall be manufactured only in the following pressure ranges: 0–30 in. vac.; 30 in.–15 lb.; 30 in.–30 lb.; 30 in.–60 lb.; 30 in.–100 lb.; 30 in.–150 lb.; 30 in.–200 lb.; 30 in.–300 lb.; 0–15 lb.; 0–30 lb.; 0–60 lb.; 0–100 lb.; 0–160 lb.; 0–200 lb.; 0–300 lb.; 0–400 lb.; 0–600 lb.; 0–800 lb.; 0–1,000 lb.; 0–1,500 lb.; 0–2,000 lb.; 0–3,000 lb.; 0–5,000 lb.; and 0–10,000 lb. There are, however, certain exceptions to these limitations. The exceptions are:

(i) Ranges are not limited for pressures lower than 15-lb. or higher than 10,000 lb. p. s. i.

(ii) Ranges are not limited for gauges manufactured for use as pneumatic receivers in conjunction with remote instrument transmitters.

(iii) Gauges used on fire fighting equipment only may be supplied with pressure ranges of 30 in.–400 lb.; 30 in.–600 lbs.; and 30 in.–800 lbs. in dial sizes of 2½ inches, 3½ inches and 4½ inches only.

(3) Altitude and metric graduations shall be limited to the equivalents of the ranges specified in paragraph (b) (2) hereof.

(4) The following items, features and devices shall be eliminated in the manufacture of gauges:

(i) Retard and suppressed scale gauges, except where required by Army or Navy specifications.

(ii) Brass cases, except where required by Army or Navy specifications, or for 4½ in. and 6 in. gauges which are manufactured with a solid or reinforced front for use in plants manufacturing compressed gases, such as, but not limited to, oxygen, hydrogen, nitrogen, helium, acetylene and carbon dioxide.

(iii) Polished rings, except where required by Army or Navy specifications.

(iv) Plated rings.

(v) Inside case illumination, except for railroad gauges.

(vi) Electric contacts on gauges larger than 2½ inches dial diameter.

(vii) Outside adjustable maximum pointers, or other outside operable pointers, except for testing machine gauges or where required by Army or Navy specifications.

(viii) Customer's name on dial.

(ix) Installation of clocks in gauge cases.

(x) Duplex gauges, except in 4½-inch dial size and in railroad gauges.

(5) Gauges in sizes 4½-inch dial diameter, or larger, shall be manufactured with the following connections only, except where otherwise required by Navy or Maritime Commission specifications:

(i) Bronze bourdon tube gauges—¼-inch pipe thread only.

(ii) Steel bourdon tube gauges—¼-inch pipe thread from 0 to 1,000 lbs. p. s. i. dial graduation inclusive; ½-inch pipe thread from 1,000 lbs. to 10,000 lbs. p. s. i. dial graduation inclusive.

Issued this 11th day of November 1943.

PART 3207 — INDUSTRIAL TYPE INSTRUMENTS, CONTROL VALVES AND REGULATORS: SIMPLIFICATION

[Schedule VII to Limitation Order L-272]

INDUSTRIAL AND GENERAL PURPOSE THERMOMETERS

§ 3207.8 *Schedule VII to Limitation Order L-272* — (a) *Definition.* This schedule applies to industrial and general purpose thermometers. Some of the provisions apply only to one or the other of those classes, and in such cases they so state. Otherwise, the provisions apply to both classes of thermometers. "Industrial thermometers" are those generally known as such by the trade. Such thermometers as the 5-inch scale Navy type are included. An industrial thermometer has a case with glass front; a mercury or liquid filled glass tube; fixed or thread, flanged, union, separable socket, or long stem connection; and a separate scale graduated in degrees. "General purpose thermometers" are those generally known as such by the trade. They include such types as cylindrical case, sterilizer, hot-water, open "v" case, and shower bath thermometers. They are generally similar in construction to industrial thermometers. Neither of these terms include such special types as cup-case, japanned tin case, etched in armor, or shiphold thermometers; nor do they include dairy thermometers manufactured to conform to Federal, State or Municipal regulations applying to the handling of milk.

(b) *Specifications.* (1) Protective finishes for case or front, if supplied, shall be paint, lacquer or enamel only.

(2) Industrial thermometer cases shall be made only in the 5-inch, 7-inch and 9-inch sizes; and only one type of case (the manufacturer's standard type) shall be furnished in each size; but the omission of glass or front from the case shall not constitute a difference in type. The provisions of this paragraph (b) (2) do not apply to fumetight cases.

(3) General purpose thermometers shall not be manufactured by any producer in more than two models. A producer may select any two models, irrespective of case, shape, or size; but any variation in case, shape or size will constitute a different model. Shape means such things as "v" shape, cylindrical, etc. Size means length and width of the case. Range and stem variations, and the presence or absence of glass or front do not constitute differences in model, however.

(4) Cases and case fronts shall not be made of copper or copper alloy other than copper tubing, copper alloy tubing, or cylindrical extruded shapes.

(5) Thermometers shall be manufactured in 90, 135, 180 and 225 degree angles only. The angle is that measured between the center line of the stem

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and the center line of the case, and is measured either in a plane normal to the face backwards from the face, or in a plane parallel to the face either to the right or left of the face. Offset angles are in no way restricted by this provision.

(6) Thermometer scales shall not have any special markings or legends, such as service markings, special markings, or colorings or graduations, operating zones, or trade names, or trade marks other than those of the producer. If special markings or legends are necessary they should be placed on tags made of non-critical materials. This provision does not apply, however, to printed scales which are in standard use by a producer for specific applications.

(7) Separable sockets shall not be supplied with caps and chains except when they are required by Navy specifications on orders for the Navy.

(8) Fahrenheit scales on industrial thermometers within the limits of minus 40 and plus 950 degrees, inclusive, shall be furnished only in the basic ranges shown in the table below. Actual scale figures shall conform as closely as standard manufacturing procedure will allow. Whenever a customer wants a scale to extend below minus 40 degrees or above plus 950 degrees, such scale may be furnished and the restrictions of this paragraph shall not apply.

TABLE OF PERMITTED SCALE RANGES
(FAHRENHEIT)

0–plus 60
0–plus 100
minus 10–plus 110 (for 5-inch scale only)
minus 40–plus 110
0–plus 160
plus 30–plus 180
plus 120–plus 220
plus 30–plus 240
plus 170–plus 270
plus 30–plus 300
plus 200–plus 360
plus 50–plus 400
plus 200–plus 500 (for 5-inch scale only)
plus 100–plus 550
plus 150–plus 750
plus 400–plus 850
plus 200–plus 950

Issued this 10th day of November 1943.

M-293

SEPT. 17, 1943

PART 3208—SCHEDULED PRODUCTS

"Part 3208—Critical Common Components", is hereby amended to read "Part 3208—Scheduled Products."

General Scheduling Order M–293, as amended April 21, 1943, is hereby amended to read as follows:

The fulfillment of requirements for the defense of the United States has created a shortage in the production of certain products for defense, for private account, and for export; and the following order is deemed necessary and appropriate in the public interest and to promote the national defense:

§ 3208.1 *General Scheduling Order M–293.*

(a) *Definitions.* For the purpose of this order.

(1) "M–293 product" means any item listed in the tables to this order except Tables 1 and 2. These items are identified in the tables as Class X, Class Y, Class Z, and unclassified. Manufacturers of Class X products must submit periodic shipping schedules to the War Production Board. Purchasers of Class Y products must get WPB approval before placing their purchase orders. In the case of Class Z products the shipping schedules of manufacturers of end products and manufacturers of component parts may be coordinated under the supervision of the claimant agency as explained in paragraph (e). The same product may be in 2 or 3 of these classifications and if so is subject to the provisions applying to each. Unclassified M–293 products, as well as classified products, are subject to the other provisions of this order.

(2) "Manufacturer" means any person to the extent that he is engaged in making an M–293 product.

(b) *Operations reports.* Each manufacturer must file an operations report on the applicable form designated in Col. of the appropriate table at the times prescribed and in accordance with the instructions accompanying the form. If no form is designated in Col. 1, no operations report need be filed.

(c) *Provisions covering Class X products.* (1) Each manufacturer of Class X products must file with the War Production Board his shipping schedule on the form shown in the appropriate table, at the times shown and in accordance with the instructions accompanying the form. In arranging the sequence of shipments on his shipping schedule, the manufacturer shall be governed by Priorities Regulation 1 unless otherwise instructed.

(2) When the schedule has been filed, it automatically becomes a "frozen schedule" under Priorities Regulation 18 and the manufacturer must schedule his production and make his shipments so as to fill the schedule without regard to preference ratings or directions from any governmental agency, except that it may be amended by the War Production Board as explained in Priorities Regulation 18 and paragraph (g) of this order. If the instructions for the appropriate form do not say how long the schedule is frozen, it is frozen for the first three calendar months which it covers.

(d) *Provisions covering Class Y products.* (1) No person shall place a purchase order with a manufacturer and no manufacturer shall accept a purchase order for any Class Y product unless the purchase order is accompanied by specific authorization of the War Production Board obtained on the form shown in the appropriate table.

(2) All authorized purchase orders for Class Y products which the manufacturer accepts and agrees to ship on the dates specified in the authorization automatically become a "frozen schedule" under Priorities Regulation 18, and the manufacturer must schedule his production and make his shipments so as to fill the schedule without regard to preference ratings or directions from any governmental agency, except that it may be amended by the War Production Board as explained in Priorities Regulation 18 and paragraph (g) of this order. A manufacturer must not accept an order which will interfere with a previously frozen schedule.

(3) A distributor who places a purchase order for a Class Y product must accompany it by an authorization as provided in subparagraph (1) above. If he buys for immediate resale, the information called for in the application for authorization must be given about his customer rather than himself. This application may be filled out and filed either by the distributor or by the customer. In either case the distributor must forward the authorization with his purchase order to the manufacturer. If the distributor is buying for stock, he must say so on his application and give all available information called for by the application form about his trade in general. A manufacturer may not transfer a Class Y product to a distribution outlet owned or controlled by him without an authorization obtained in the same way as if he were selling it to a distributor. The term "distributor" includes wholesalers, retailers, jobbers, sales agencies, and consignees for sale.

(e) *Provisions covering Class Z Products.* (1) A prime contractor or manufacturer must accompany his purchase orders for Class Z products with the form shown in the table when he is instructed to do so by a claimant agency. Such instructions will be given only for the programs listed in Table 1. In cases where no such instructions are given, this paragraph (e) does not apply.

(2) A manufacturer of a Class Z product who receives a purchase order covered by the form referred to above must complete the form and return it. If the form includes a list of components of his product which are themselves Class Z products, then he must also fill out another copy of the form and accompany each purchase order for any of the listed components with the form. He must use the form to cover only the listed components which he needs to fill the orders received by him.

(3) If a Class Z product is also a Class X or a Y product, a purchase order covered by the appropriate form becomes part of a "frozen schedule" only in the manner explained in paragraph (c) or (d) above. If the Class Z product is not also a Class X or a Class Y product, then, even though the purchase order is covered by the form, it does not become part of a frozen schedule unless the person who places the order gets the approval of the War Production Board to the freezing of his supplier's schedule. If approval is obtained, and the manufacturer with whom the order is placed accepts the same and agrees to ship on the dates specified in the form, then the order automatically becomes part of a "frozen schedule" under Priorities Regulation 18 and the manufacturer must schedule his production and make his shipments so as to fill the schedule without regard to preference ratings or directions from any governmental agency, except that it may be amended by the War Production Board as explained in Priorities Regulation 18 and in paragraph (g) of this order. A manufacturer must not accept an order which will interfere with a previously frozen schedule.

(f) *Deviations from a frozen schedule.* If a manufacturer is unable to fulfill on time a frozen schedule for any M–293 product, he must make shipments, as far as practicable, in the sequence required by the schedule. In any case where the scheduled dates of shipments will be appreciably affected by a delay in or acceleration of production, the manufacturer shall notify the War Production Board of the reason for the delay or acceleration and the revised dates on which he expects to be able to make shipments under each purchase order affected.

(g) *Other scheduling provisions.* With respect to any M–293 products, the War Production Board may, notwithstanding any other order, preference rating, directive, rule or regulation (except Priorities Regulation 18) of the War Production Board, or of any other Governmental Agency:

(1) Revoke any authorization or approval to place a purchase order granted by it under paragraph (d) or (e) above;

(2) Direct the return or cancellation of any purchase order on the books of a manufacturer;

(3) Direct changes in the shipping schedule of a manufacturer;

(4) Cancel purchase orders placed with one manufacturer and direct that they be placed on another manufacturer;

(5) Take such other action as it deems necessary with respect to the production of, the placing of purchase orders for, or the shipment of M–293 products.

(h) *Appeals.* Any appeal from the provisions of this order shall be made by filing a letter in triplicate, referring to the particular provisions appealed from, and stating fully the grounds of the appeal.

(i) *Reports and communications.* The list of M–293 products is arranged so that the name of the Industry Division appears at the top of the table covering M–293 products for which it is primarily responsible. All reports and forms required by the order and all appeals should be addressed to the War Production Board, Washington, D. C., attention of the appropriate Industry Division so listed. All reports and forms required in paragraphs (b), (c), (d), (e), (f), and (g) of this order have been approved by the Bureau of the Budget pursuant to the Federal Reports Act of 1942.

(j) *Application of other orders and regulations.* The listing of any M–293 product under this order relieves all persons from complying with the indicated provisions of the orders shown in Table 2 (§ 3208.3).

(k) *Violations.* Any person who wilfully violates any provisions of this order, or who in connection with this order wilfully conceals a material fact or furnishes false information to any department or agency of the United States, is guilty of a crime, and upon conviction may be punished by fine or imprisonment. In addition, any such person may be prohibited from making or obtaining further deliveries of, or from processing, or using material under priority control; and may be deprived of priorities assistance.

Effective date. This order, as amended, and Tables 1 through 13 shall become effective September 24, 1943.

Issued this 17th day of September 1943.

Type of scheduled products M–293	Designation	Applicable forms column 6		
		1	2	3
1. Capacitors (fixed)		3002.17		
a. Ceramic capacitors				
b. Electrolytic capacitors				
c. Mica capacitors				
d. Paper capacitors				
e. Capacitors for power factor correction (rated in K. V. A.)	X		2809	
2. Coaxial cable—radio frequency		3002.16		
a. Solid-dielectric synthetic-insulation				
b. Gas- or air-filled rigid lines				
3. Industrial type instruments:				
a. Control valves (Purchase orders of $5,000 or more)	Y	3002.40		1319.2
b. Liquid level controllers (Purchase orders of $5,000 or more)	Y	3002.40		1319.2
c. Control valves and liquid level controller combined. (Purchase orders of $5,000 or more)	Y	3002.40		1319.2
A person shall not subdivide his purchase orders or requirements for the purpose of avoidance of the provisions of 3a, 3b, and 3c, above.				
d. Pyrometers		3002.40		
e. Regulators		3002.40		
f. Pressure instruments:				
Dial pressure indicators		3002.41		
Recording and controlling pressure instruments		3002.40		
g. Temperature tube system instruments		3002.40		
h. Flow metering instruments		3002.40		
i. Industrial thermometers		3002.40		
j. Combustion control equipment				
k. Strainers (as manufactured only by industrial instrument producers)		3002.40		
l. Liquid level mechanisms		3002.40		
4. Electrical indicating instruments. A measuring mechanism, the pointer of which responds to a change in an electrical quantity, including instrument mechanisms and instrument relays made therefrom, also small panel, switchboard, and aircraft electrical instruments, but not including the following:				
(1) Instruments made with metal bearings and normally used in automotive vehicles or mobile construction machinery; (2) Electrical aircraft self-synchronous indicators or transmitters; (3) Electrical test instruments as classified below under 6 (h)		1685		
(a) Purchase orders covering electrical indicating instruments except (1) any order for less than 500 identical electric indicating instruments which conform to the ranges and dimensions established and prescribed for "Electrical Indicating Instruments" by American War Standards C39–2–1943 as approved January 6, 1943 and published by the American Standards Association; (2) any order for less than 500 identical electrical indicating instruments of flange diameter, height or width exceeding 3½ inches; (3) any order for polarized vane, non-jeweled instruments; (4) any order for less than 500 identical electrical indicating instruments which conform to approved U. S. Army or Navy specifications specified on the order	Y			1682
5. Resistors, fixed and variable		3002.18		
6. Electrical test equipment and test instruments (standard types). There shall not be included in any case: (1) Test equipment made for his own use by a manufacturer who does not offer a similar type of test equipment for sale commercially; (2) Test equipment produced on direct Army or Navy orders by a manufacturer who does not offer a similar type of test equipment for sale commercially.				
(a) *Radio frequency generators*				
(1) Standard laboratory type (below 50 MC)	XY	3002.21	3001.21	3203
(2) FM standard laboratory type (below 50 MC)	XY	3002.21	3001.21	3203
(3) Ultra high frequency type (below 500 MC)	XY	3002.21	3001.21	3203
(4) FM ultra high frequency type (below 500 MC)		3002.21		
(5) Very high frequency type		3002.21		
(6) Test oscillator type	XY	3002.21	3001.21	3203
(b) *Audio frequency generators:*				
(1) Variable frequency type	XY	3002.21	3001.21	3203
(2) Square wave type		3002.21		
(3) Fixed frequency type		3002.21		
(c) *Radio frequency measuring equipment:*				
(1) Wavemeter-absorption type	XY	3002.21	3001.21	3203
(2) Wavemeter-heterodyne type	XY	3002.21	3001.21	3203
(3) RF noise meter	XY	3002.21	3001.21	3203
(4) Field strength meter	XY	3002.21	3001.21	3203
(5) Calibrator		3002.21		
(6) Modulation monitor		3002.21		
(7) Interpolation oscillator	XY	3002.21	3001.21	3203
(d) *Audio frequency measuring equipment*				
(1) Audio frequency meters, electronic	XY	3002.21	3001.21	3203
(2) Analyzer, wave or harmonic	XY	3002.21	3001.21	3203
(e) *Universal measuring equipment:*				
(1) Laboratory oscilloscope	XY	3002.21	3001.21	3203
(2) Service oscilloscope	XY	3002.21	3001.21	3203
(3) Signal tracer		3002.21		
(4) Q meter	XY	3002.21	3001.21	3203
(f) *Bridges:*				
(1) Wheatstone	XY	3002.21	3001.21	3203
(2) Megohm	XY	3002.21	3001.21	3203
(3) Kelvin	XY	3002.21	3001.21	3203
(4) Resistance limit		3002.21		
(5) Impedance	XY	3002.21	3001.21	3203
(6) Capacitance	XY	3002.21	3001.21	3203
(7) Capacitance limit	XY	3002.21	3001.21	3203
(8) Inductance	XY	3002.21	3001.21	3203
(g) *Miscellaneous electronic equipment:*				
(1) Stroboscopes	XY	3002.21	3001.21	3203
(2) Laboratory audio frequency amplifiers		3002.21		
(3) Sound and vibration meters	XY	3002.21	3001.21	3203
(4) Direct current amplifiers		3002.21		
(5) Precision variable condensers	XY	3002.21	3001.21	3203
(6) Primary frequency standards	XY	3002.21	3001.21	3203
(h) *Electrical test instruments* (including portable instruments). An electrical test instrument of the general types listed below is one normally connected to the circuit under test for a temporary reading. (Portable instruments such as portable voltmeters and ammeters are included in this group.) The model number designations below apply to the instruments which are given that identification by the manufacturer, and the provisions of this order apply to those instruments regardless of any different identification given them on purchase orders or otherwise. No person shall avoid the provisions of this order by changing any model number designation specified below				

[1] A manufacturer of a Class X product must file his shipping schedule on Form WPB 3003, 3401, or on the form shown in Column 2.

A person placing an order for a Class Y product must use the form shown in Column 3 to obtain WPB authorization.

M-293

TABLE 1

OCTOBER 13, 1943

PROGRAMS

§ 3208.2 *Table of programs.* (a) The following table is issued pursuant to the provisions of General Scheduling Order M-293:

Paragraph (e) applies only to orders for Class Z products for the programs and claimant agencies shown in the following list:

Ships as programmed by the Navy Department, the Maritime Commission and the War Department.

Advanced and Overseas Bases as programmed by the Navy Department.

Tanks, Combat Vehicles and motor transport vehicles as programmed by the War Department.

Power generating plants as programmed by the Office of War Utilities.

Plants designed for the production of rubber as programmed by the Office of the Rubber Director.

Plants designed for the production of high octane gasoline as programmed by the Petroleum Administration for War.

Programs corresponding to the above as programmed by the Canadian Department of Munitions and Supply and approved by the Canadian Division, War Production Board; or, in the case of plants designed for the production of rubber, approved by the Office of the Rubber Director; or, in the case of plants designed for the production of high octane gasoline, approved by the Petroleum Administration for War.

Issued the 13th day of October 1943.

M-293

TABLE 2

SEPT. 17, 1943

OTHER SCHEDULING ORDERS

§ 3208.3 *Other scheduling orders.* (a) Pursuant to paragraph (j) of General Scheduling Order M-233, all persons are relieved from complying with the following provisions of War Production Board orders for products listed on the Tables to General Scheduling Order M-293:

M-76, all provisions.

L-100, all provisions except that the order remains effective as to secondhand or reconditioned equipment.

L-117, all provisions.

L-163, all provisions.

L-172, all provisions except paragraphs (d) (2) and (d) (3).

L-193, provisions of paragraph (b) (1), the first sentence only of sub-paragraph (c) (1), paragraph (d), and paragraph (f).

L-203, provisions of paragraphs (b) (1) and (b) (2).

L-234, all provisions.

E-6, provisions of paragraph (d) (2).

E-10, provisions of paragraph (c) and (d).

Issued the 17th day of September 1943.

M-293

TABLE 9

NOV. 13, 1943

[As Amended]

RADIO AND RADAR DIVISION

§ 3208.10 *Table for Radio and Radar Division.* (a) The following amended table is issued pursuant to the provisions of General Scheduling Order M-293:

Issued this 13th day of November 1943.

Type of scheduled products M-293	Designation	Applicable forms column 1	2	3
1. Testers:				
A. Vacuum tube voltmeters, electronic Volt-Ohmmeters, and Volt-Ohm-Milliammeters (all models)		3002.21		
Hewlett-Packard Company: Model 400-A	XY	3002.21	3001.21	3243
Ballantine Laboratories, Inc.: Model 300-A	XY	3002.21	3001.21	3243
General Radio Company: Model 726-A	XY	3002.21	3001.21	3243
Hickok Electrical Inst. Co.:				
Model 110	XY	3002.21	3001.21	3243
Model 202	XY	3002.21	3001.21	3243
Radio City Products: Model 662	XY	3002.21	3001.21	3243
Precision Apparatus Company:				
Model EV-10	XY	3002.21	3001.21	3243
Model 1-107	XY	3002.21	3001.21	3243
RCA Victor Division of RCA Model 165-A	XY	3002.21	3001.21	3243
All other models—Purchase orders for 5 or more units	Y			3243
B. High sensitivity (20,000 ohms per volt and over, not electronic) (Volt-Ohmmeters and Volt-Ohm-Milliammeters, including instruments with decibel and capacity ranges		3002.21		
Triplett Electrical Inst. Co.:				
Model 1200-F	XY	3002.21	3001.21	3243
Model 1200-E	XY	3002.21	3001.21	3243
Model 1600-E	XY	3002.21	3001.21	3243
Weston Electrical Inst. Corp.:				
Model 772	XY	3002.21	3001.21	3243
Model 785 (All types)	XY	3002.21	3001.21	3243
Simpson Electric Co. Model 260	XY	3002.21	3001.21	3243
Precision Apparatus Company Model 856	XY	3002.21	3001.21	3243
Supreme Instruments, Inc., Model 592	XY	3002.21	3001.21	3243
All other models—Purchase orders for 5 or more units	Y			3243
C. Medium sensitivity (5,000 to 19,000 ohms per volt sensitivity) Volt-Ohmmeter, Volt-Ohm-Milliammeters, including instruments with decibel and capacity ranges		3002.21		
Simpson Electric Company Model 215	XY	3002.21	3001.21	3243
Triumph Manufacturing Company Model 351	XY	3002.21	3001.21	3243
Supreme Instruments, Inc. Model 542	XY	3002.21	3001.21	3243
Triplett Electrical Inst. Co. Model 606-B	XY	3002.21	3001.21	3243
All other models—Purchase orders for 5 or more units	Y			3243
D. Low sensitivity (below 5,000 ohms per volt sensitivity) Volt-Ohmmeter, Volt-Ohm-Milliammeter including instruments with decibel and capacity ranges		3002.21		
Clough-Brengle Company: Model OAE (285)	XY	3002.21	3001.21	3243
Weston Electrical Instrument Corp.:				
Model 564	XY	3002.21	3001.21	3243
Model 665	XY	3002.21	3001.21	3243
Model 697	XY	3002.21	3001.21	3243
Triplett Electrical Inst. Co.:				
Model 666	XY	3002.21	3001.21	3243
Model 666H	XY	3002.21	3001.21	3243
Model 1200A	XY	3002.21	3001.21	3243
Supreme Instruments, Inc.:				
Model 537	XY	3002.21	3001.21	3243
Model 543	XY	3002.21	3001.21	3243
Model 543-S (TE-50)	XY	3002.21	3001.21	3243
Precision Apparatus Company: Model 844	XY	3002.21	3001.21	3243
Simpson Electric Company:				
Model 230	XY	3002.21	3001.21	3243
Model 235	XY	3002.21	3001.21	3243
Model 240	XY	3002.21	3001.21	3243
Model 324	XY	3002.21	3001.21	3243
Model 443	XY	3002.21	3001.21	3243
All other models—Purchase orders for 5 or more units	Y			3243
2. Tube testers (All types including combination tube and set testers)		3002.21		
General Communications Company Electronic Tube Tester	XY	3002.21	3001.21	3243
Precision Apparatus Company:				
Model 910	XY	3002.21	3001.21	3243
Model 920	XY	3002.21	3001.21	3243
Supreme Instruments, Inc.: Model 504A	XY	3002.21	3001.21	3243
Triplett Electrical Inst. Co.:				
Model 1183 SC	XY	3002.21	3001.21	3243
Model 1213	XY	3002.21	3001.21	3243
Model 1612	XY	3002.21	3001.21	3243
Model 1613	XY	3002.21	3001.21	3243
Hickok Electrical Instrument Co.:				
Model 510	XY	3002.21	3001.21	3243
Model 530	XY	3002.21	3001.21	3243
Model 540	XY	3002.21	3001.21	3243
Model 545	XY	3002.21	3001.21	3243
Model 550X	XY	3002.21	3001.21	3243
Model 560	XY	3002.21	3001.21	3243
All other models—Purchase orders for 5 or more units	Y			3243
3. Output meters		3002.21		
Radio City Products Model 471	XY	3002.21	3001.21	3243
Daven Company:				
Model D-180	XY	3002.21	3001.21	3243
Model OP-182	XY	3002.21	3001.21	3243
Model OP-193	XY	3002.21	3001.21	3243
General Radio Company:				
Model 483	XY	3002.21	3001.21	3243
Model 583	XY	3002.21	3001.21	3243
Simpson Electric Company Model 427	XY	3002.21	3001.21	3243
Triplett Electrical Inst. Co. Model 650 SC	XY	3002.21	3001.21	3243
Weston Electrical Inst. Co. Model 571	XY	3002.21	3001.21	3243
All other models on purchase orders of $25.00 net or more under this heading	Y			3243
4. Ohmmeters, megohmmeters, and megger testers		3002.21		
Shallcross Manufacturing Company: Model 684	XY	3002.21	3001.21	3243
James G. Biddle Company:				
Model 703	XY	3002.21	3001.21	3243
Model 704	XY	3002.21	3001.21	3243
Model 705	XY	3002.21	3001.21	3243
Weston Electrical Inst. Corp.: Model 796	XY	3002.21	3001.21	3243
All other models on purchase orders of $25.00 net or more under this heading	Y			3243
5. Portable electrical indicating instruments		3002.21		
Weston Electrical Inst. Corp.: Model 622	XY	3002.21	3001.21	3243
Rawson Electrical Instrument Co.:				
Model 501	XY	3002.21	3001.21	3243
Model 501A	XY	3002.21	3001.21	3243
Model 502	XY	3002.21	3001.21	3243
Model 502A	XY	3002.21	3001.21	3243
Sensitive Research Instrument Co.: All models	XY	3002.21	3001.21	3243
All other models—Purchase orders for 100 or more units	Y			3243
7. Vacuum tubes, electronic (excluding X-ray tubes and tungar type rectifiers)		1093		

Interval Timers

Process Timers

Signal Timers

Time Switches

Relays

Write

AUTOMATIC
ELECTRIC
MANUFACTURING CO.
MANKATO, MINNESOTA

[Table 12 to General Scheduling Order M-293]

TOOLS DIVISION

§ 3208.13 *Table for Tools Division.*

(a) The following table is issued pursuant to the provisions of General Scheduling Order M-293:

Issued this 17th day of September 1943.

Type of M-293 product	Designation	Applicable forms column 1		
		1	2	3
1. Bearings, ball and roller		1314		
2. Mechanics' hand service tools		2057 3001.45		
a. Adjustable wrenches (crescent type)				
b. Socket wrenches				
c. Monkey wrenches				
d. Pliers, side cutting				
Purchase orders totalling the following amounts for the items a through d, inclusive: Adjustable wrenches (crescent type) $10,000; socket wrenches $50,000; monkey wrenches $2,000; pliers, side-cutting $10,000; (purchase orders shall not be subdivided for the purpose of evading this requirement)	Y			1319.34
3. Metal cutting tools		39		
a. Threading chasers for die heads and collapsible taps				
4. Precision measuring tools		2009		
a. Micrometers				
b. Internal micrometers				
c. Calipers, pocket slide				
d. Planer gages				
e. Thickness gages				
f. Telescope gages				
g. Precision levels				
h. Parallels				
i. Protractors				
j. Solid squares				
k. Steel rules				
l. Vernier calipers				
m. Vernier, gear tooth				
n. V blocks				
5. Hammers, forging		1440		
6. Presses, mechanical and hydraulic (metal working)		1440		
7. Extruding machines (metal)		1440		
8. Machine tool attachments and accessories				
a. Lathe chucks		3002.32		
b. Die Heads		39		
c. Collapsible taps		39		
9. Machine tools		417		
a. Surface broaching machines (5 to 15 tons)				
b. Planers, double housing (48" and up)				
c. Thread milling machines				
d. Thread grinding machines (8" and up)				
e. Cylindrical grinding machines				
f. Precision boring machines				
g. Special and way drilling machines				
h. Spur and helical gear shaping machines				
i. Special machines (various types)				
10. Chain, excluding stud link anchor and power transmission		2064		

[1] A person placing an order for a Class Y product must use the form shown in Column 3 to obtain WPB authorization.

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900 WEST CERMAK ROAD
CHICAGO, ILL.

Instruments in the War Effort

Plastic "Bomber Nose" Speeds Altitude Testing

AN amazingly simple altitude test chamber for aircraft radio and electronic equipment, in which engineers can see the entire apparatus in operation under conditions duplicating the stratosphere seven and one-half miles up, has been developed by the RCA Victor Division of the Radio Corporation of America. This simple chamber, constructed of the transparent nose cone of a bomber, is helping to speed delivery of radio equipment to air services from the company's Camden plant where these new chambers are in operation.

Built of transparent Plexiglas, a plastic developed by the Rohm and Haas Co., the chamber is actually the unfinished nose of a famous American bombing plane. Transparent construction makes possible the complete testing and inspection of any piece of radio apparatus by several engineers at one time and materially speeds test work. This new construction is said to have eliminated difficulties found with standard test chambers constructed of metal and permitting vision only through small portholes.

Defects in design, which normally would remain hidden until actual high altitude flights could be made, are spotted at a glance. An entire complement of test instruments may be connected

Continued on page 772

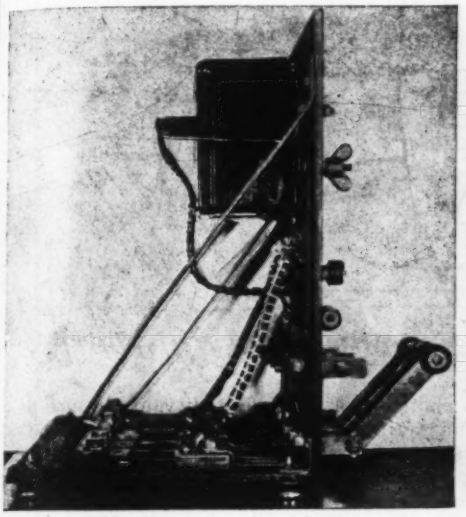
APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. II, No. 12 M. F. Behar, Editor December 1943

'Home-made' Devices Built Far Away from Home!



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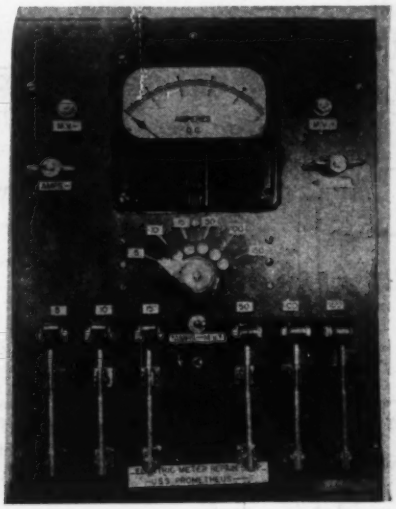

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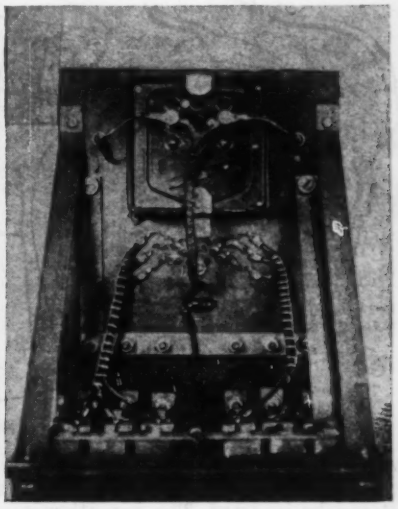


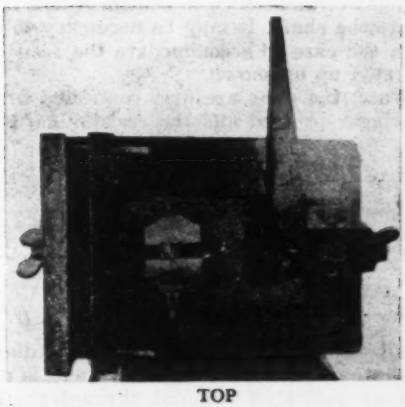
REAR

By ARTHUR L. BECKER

Chief Electrician's Mate, U.S.S. Xxxxxx, U. S. Navy

ENCLOSED are two sets of photographs which it is hoped will be of some use in your Shop Ideas. We are prompted to submit them in the expectation that they may be of value in furthering the War Effort. The first set shows our own Ammeter and Shunt Calibration Board. The other set shows our own repair fixture for electrical instruments, incorporating a moving-coil jig, which we have been using since June 1942.

[EDITOR'S NOTE—Ordinarily, we would ask the author to supply working details before accepting such an "article" but the author's Fleet P.O. address, suggesting the antipodes, impelled us to make an exception in favor of a member of a *busy* "ground crew afloat" . . . and to pay him our full Shop Kinks rate—in time for Christmas, we hope!]



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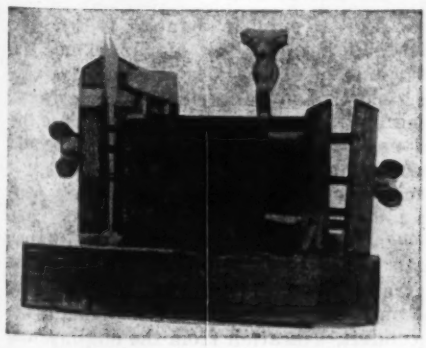

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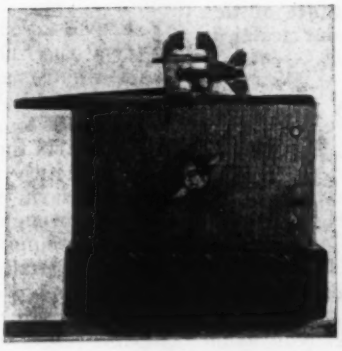

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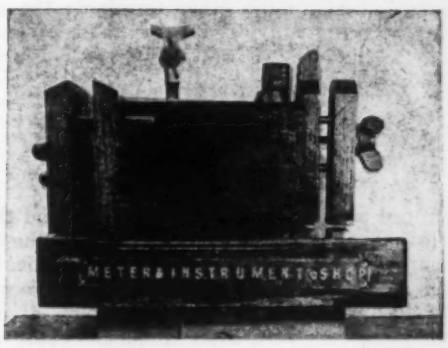


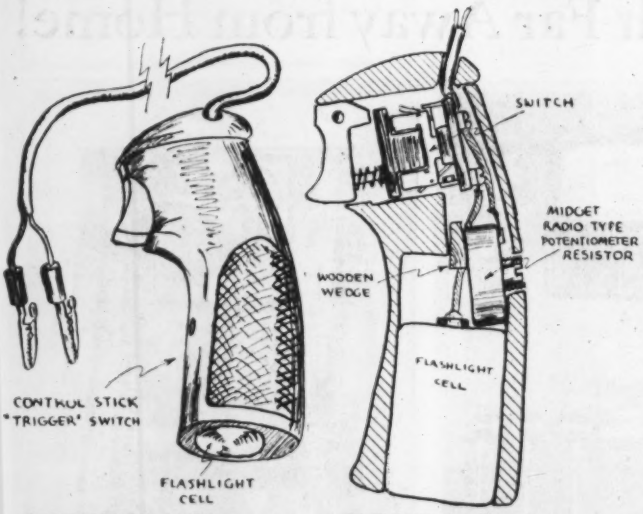
FRONT

Troubleshooting on Cylinder Head Temperature Installations

By M. J. WIGGINS
Vero Beach, Fla.

ALTHOUGH cylinder head temperature installations are simple, it often is difficult to tell which part of a system is at fault, particularly in planes which have the leads hidden from view and the thermocouple hard to see. With this little tester the trouble can be located quickly, with a saving in both time and temper.

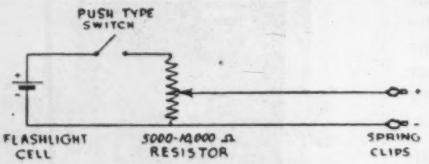
The tester comprises a flashlight cell, a potentiometer resistor, a push-type switch and necessary leads. These may be mounted in any manner convenient. However, the "make-up" used here forms a neat and compact unit, so it will be described. The case is made from a salvaged control stick



ASSEMBLED VIEW CUT-AWAY VIEW

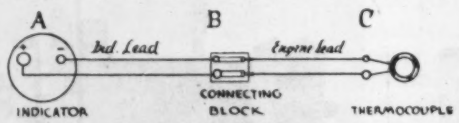
switch assembly of the pistol-grip type which has a trigger switch. By reaming out the stick-hole a standard flashlight cell can be inserted. The potentiometer resistor is a screwdriver-adjustable midget type and is installed above the flashlight cell as shown in sketch. A hole is drilled to accommodate the shaft. It may be necessary to enlarge the opening in the case to accommodate the resistor. The leads are connected up as shown.

To use, the clips are first connected to a good indicator, the trigger pressed and the resistor adjusted to give about



TEST UNIT HOOK-UP

¾ full-scale reading. Referring to the diagram of a typical installation, it will be seen that there is a complete circuit, from one indicator terminal, through the leads and thermocouple, back to the other terminal; the resistance of this circuit being only 2 ohms in most cases. If our tester is



TYPICAL CYL. TEMP HOOK-UP

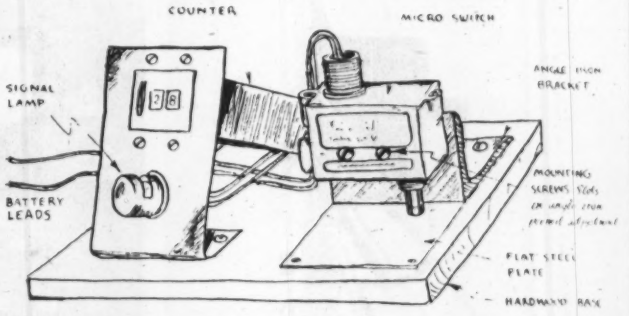
clipped across the indicator (at *A*) and the trigger pulled, the indicator would barely flicker as the lead and thermocouple effectively short-circuit the indicator. If this were the case, the leads and thermocouple are probably O.K. and the indicator is at fault. However, if the leads or the thermocouple were broken, the indicator would read about ¾ scale. Then, by moving the clips to the connection block on the firewall (at *B*) the indicator lead can be checked, and, if O.K., the clips moved to the thermocouple connections (at *C*). If the indicator reads from this point, the thermocouple is bad and should be replaced.

Grounds and shorts can be located in a similar manner without danger to the sensitive indicator, which can be damaged by using an ohmmeter.

Gasket Thickness Tester

By M. J. WIGGINS
Vero Beach, Fla.

AFTER aircraft spark plug gaskets have been used they must be "miked" before they can be used again. If the gasket is less than 0.072" thick it must be discarded as it would allow the plug to extend too far into the combustion chamber and possibly fail. Measuring several hundred gaskets by hand with a micrometer is a long and tedious job. With the little tester described the gaskets can be quickly checked and the good gaskets automatically counted.



SORTER and COUNTER for SPARK PLUG GASKETS

No credit is claimed for the originality of the use of a Micro-switch for gaging. However, in view of the fact that all of the parts were obtained from scrap and resulted in a large saving of time, this unit might suggest a similar use to others.

The sketch should be self-explanatory. A Micro-switch salvaged from a wrecked plane was mounted as shown, slots in the angle iron bracket allowing the switch to be adjusted so that it will make at 0.072". The lamp and the counter (which is an ammunition rounds counter, also salvaged) are connected to the proper voltage battery in series with the Micro-switch. The lamp will light and the counter will move every time a good gasket is slid under the plunger. A bad gasket will not register. The flat steel plate which forms the anvil should be polished and kept coated with a thin film of light oil to prevent rusting.

Note: If a space rounds counter is used the numbers will have to be changed as they run backwards originally.

A Hint on Fuel Quantity Gages

By M. J. WIGGINS
Vero Beach, Fla.

I HAVE encountered a great number of faulty G-E Selsyn type fuel quantity gage systems, all of which had the same trouble, all of which were cured by the same treatment. The following report of my experience may perhaps save others some time and work. The trouble is not in the Selsyn parts themselves and therefore could not be detected during factory inspection and testing.

The Selsyn transmitter obtains its positive battery connection through one plug contact but depends on the case for its ground or negative battery connection. In planes using self-sealing gas cells, the rubber cell insulates the float assembly and transmitter from the fuselage of the plane; therefore, the only ground connection is through the flexible shielding or conduit. Vibration from the engines and from landing gear under wing tanks loosens the conduit

Teamwork Made America First in the Air!

THE urgency of creating our great Allied air armadas required a production capacity many times that of America's aviation industry. So it invited thousands of manufacturers in many fields to "team up" in the vast program of making America *first* in the air.

Kollsman joined in this effort by "schooling" over a score of manufacturers in the difficult techniques of building complete Kollsman aircraft instruments.

Kollsman immediately threw open its facilities to the engineers of coöperating plants. Step by step, Kollsman engineers revealed to them in minute detail the intricate techniques of mass-producing these vital precision products. And then they frequently went into those plants and helped work out production . . . and kept at it until the last "bug" was ironed out.

It isn't easy to build instruments that meet Kollsman specifications. But our "team" is doing just that . . . and in ever-increasing volume. While this work goes forward, Kollsman is busy at the task of developing aircraft instruments to meet new flight problems.

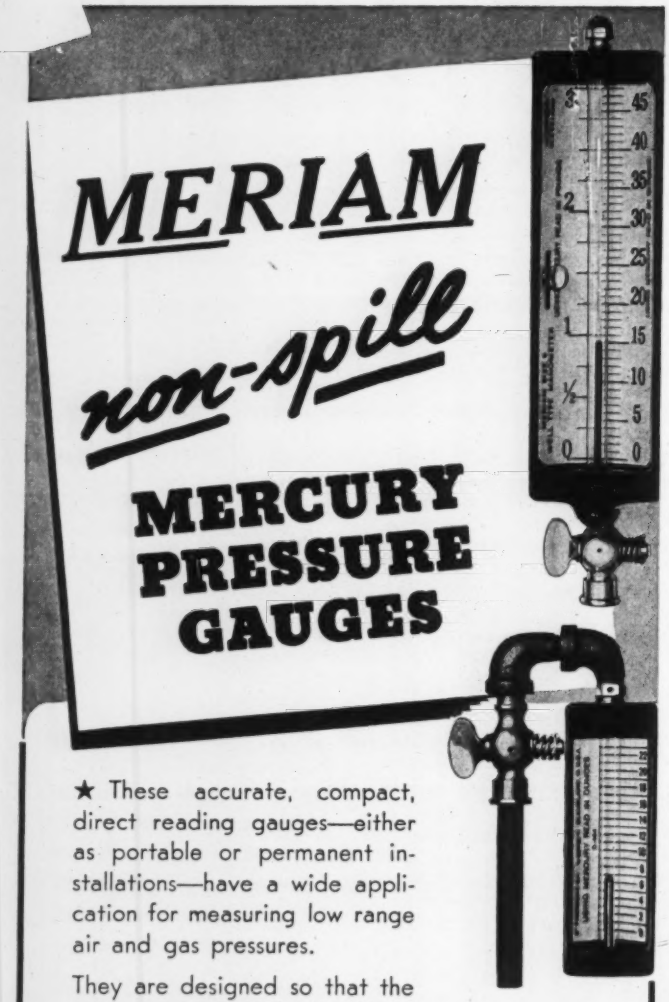
THE KOLLSMAN 50,000 FT. SENSITIVE ALTIMETER *is so ingeniously geared that a diaphragm expansion of only three-sixteenths of an inch sends the pointer around the dial 50 times! Capable of measuring altitude to within a few feet, its essential parts are finished to within two ten-thousandths of an inch.*

KOLLSMAN AIRCRAFT INSTRUMENTS

PRODUCT OF

SQUARE D COMPANY

ELMHURST, NEW YORK • GLENDALE, CALIFORNIA



★ These accurate, compact, direct reading gauges—either as portable or permanent installations—have a wide application for measuring low range air and gas pressures.

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The following articles have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

Fuel Mixture Indicators

By SIMON S. JACKEL
Instructor, Aircraft Instruments, Army Air Forces Eastern Technical Training Command, Yale University, New Haven, Conn.

INTRODUCTION

FUEL MIXTURE INDICATORS are used as a guide in setting the mixture controls on many types of airplanes not having automatic mixture controls. It has been shown conclusively that proper use of the fuel mixture indicator results in excellent engine performance at maximum gasoline economy. A study of the operations of one of the large commercial airlines has indicated a considerable saving in the amount of gasoline consumed since fuel mixture indicators were installed. Several manufacturers have fuel mixture indicators on the market. This writer is familiar with the Breeze, Cambridge, and Englehardt makes, and believes that they are all basically similar in their operating principles, general design, installation, maintenance and overhaul procedures. For the purpose of this article, the fuel mixture indicators manufactured by the Cambridge Instrument Company of New York City will be used as an example. It should be understood that with minor changes this article is applicable to the instruments manufactured by other companies.

PART I—GENERAL PRINCIPLES

The fuel mixture indicator measures and indicates the ratio of air and fuel, by weight, of the fuel mixture entering the engine. An indication, for instance, of 0.066 indicates a fuel mixture consisting of 15 parts of air to 1 part of gasoline. At the other end of the scale, an indication of

WITH three years' experience instructing in all kinds of aircraft instruments at Chanute Field, Rantoul, Illinois, plus a Bachelor of Science degree for a background, Simon S. Jackel comes forth with this most complete article on Fuel Mixture Indicators.

Let me sound off to all: A few more members like Mr. Jackel would certainly go a long way toward making our Aircraft Instrument Guild a complete success. I hope we will let Mr. Jackel know how we appreciate his hours of effort to broaden our scope of knowledge—if not to him directly, at least by submitting articles of your own. —R. G. OJERS

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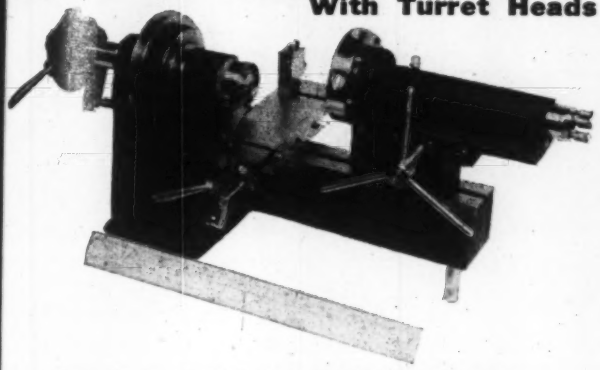

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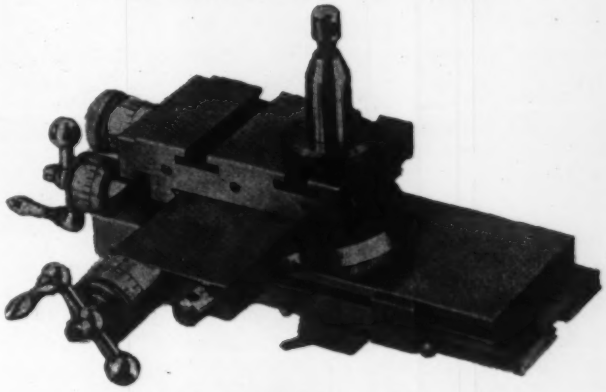

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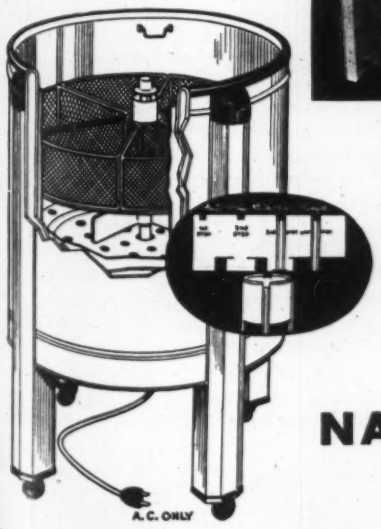

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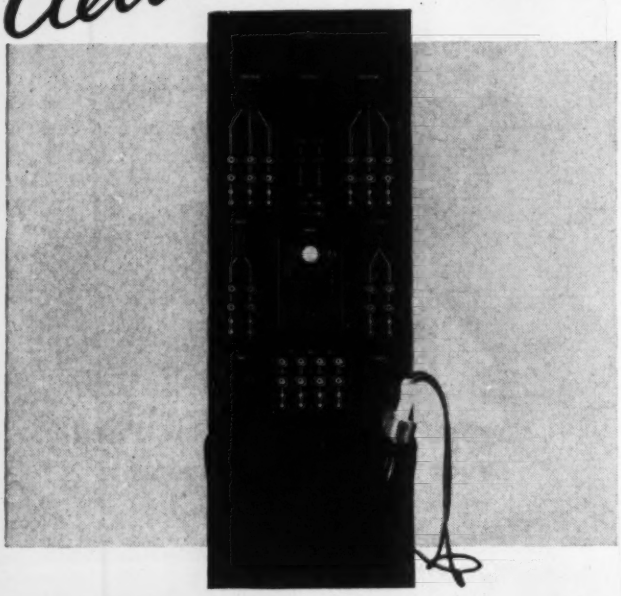

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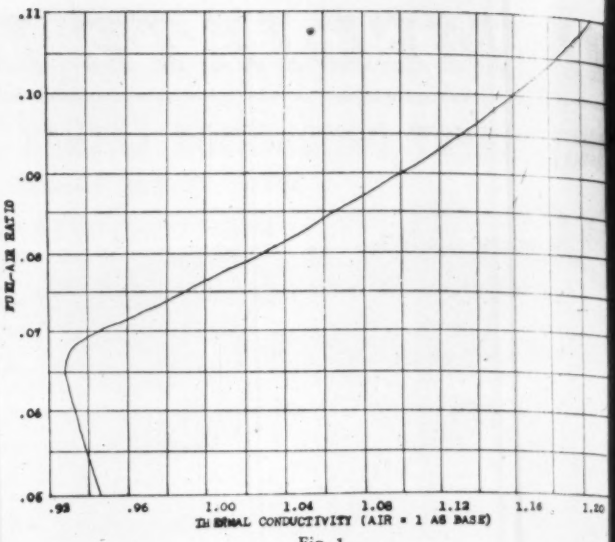

Fig. 1.

0.110 indicates a fuel mixture consisting of 9 parts of air t 1 part of gasoline. The reading 0.077 (often labeled "A on the indicator) indicates 13 parts of air to 1 of gasoline The lower the reading the leaner the mixture, where th reading is the decimal equivalent of the fraction resultin from one part of gasoline to so many parts of air in th fuel mixture.

This indication is obtained by analysis of the exhaus gases resulting from combustion of the fuel mixture. Th chemical composition of the exhaust gases varies with th composition of the initial fuel mixture. The exhaust gase from a 0.070 (lean) fuel mixture, for instance, contai approximately 12.6% carbon dioxide, 0.3% hydrogen, an 1.1% carbon monoxide. As the mixture is enriched, th carbon dioxide content decreases while the carbon monoxid and hydrogen content increases. A 0.090 (rich) fuel mix ture gives exhaust gases containing approximately 9.0% carbon dioxide, 4.6% hydrogen, and 7.2% carbon monoxide

The analysis in the airplane is made possible by the fac that the thermal conductivity of the exhaust gases (abilit to cool a hot wire by carrying heat away) varies with th chemical composition. As a standard of thermal conduc tivity, water-saturated air is used and assigned the valu 1.00. The 0.070 mixture exhaust has a thermal conductivit of 0.94, while the 0.090 mixture exhaust has a therma conductivity of 1.10. The exhaust gases of the mixture 0.07 (labeled "A") have a thermal conductivity of 1.00. Thi means that a heated wire placed in each of the three ex hausts would cool most rapidly in the 0.090 fuel mixture exhaust, least rapidly in the 0.070 fuel mixture exhaust and at an intermediate rate in the 0.077 fuel mixture ex haust. Note that the 0.077 mixture exhaust has the same thermal conductivity as the standard — water-vapor-satu rated air (1.00). Richer mixtures, then, give exhaust gase that cool more rapidly than the standard (air), while lean mixtures give exhausts that cool less rapidly. Fig. 1 shows the relationship between gasoline-air ratio and thermal conductivity of the exhaust gases.

Since a fixed relation exists between thermal conductivity of the exhaust gases and the fuel air ratio of the precombustion mixture, measurement of the thermal conductivity will indicate the nature of the fuel mixture. This is accomplished electrically by taking advantage of the fact that the resistance of a platinum spiral (also true of most conductors) increases as its temperature increases and decreases with a decrease in temperature. Thus, a heated spiral exposed to the exhaust of a rich mixture will be at a lower temperature than one exposed to moisture-saturated air. Likewise, a heated spiral exposed to the exhaust of a lean mixture will be at a higher temperature than one exposed to moisture-saturated air.

In the instrument, four platinum spirals forming the four arms of a Wheatstone bridge electric circuit are employed. These spirals are enclosed in separate cells encased

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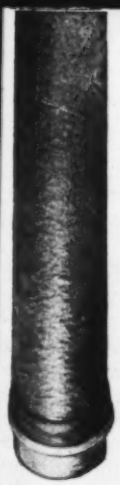

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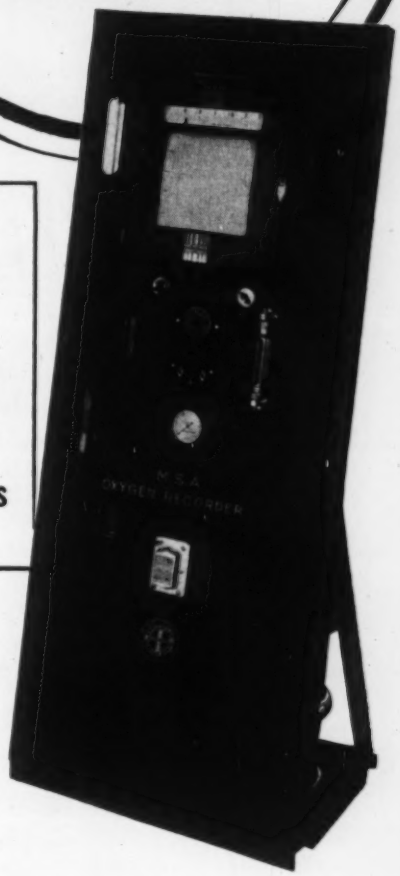

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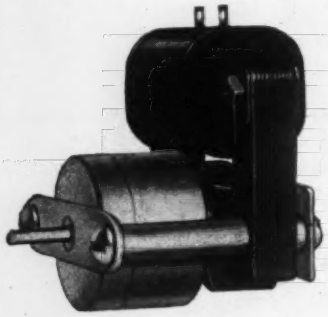

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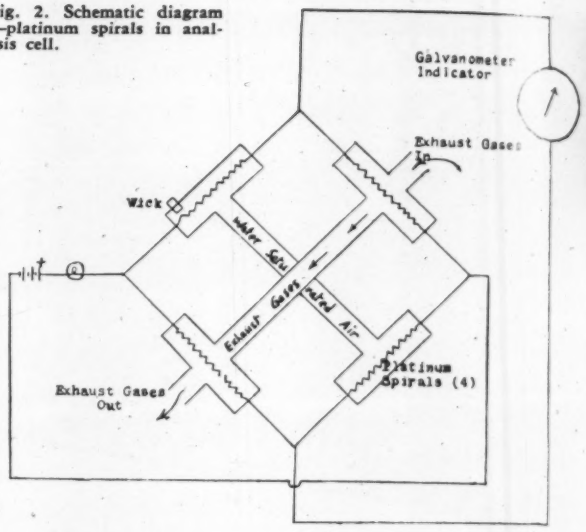
Fig. 2. Schematic diagram —platinum spirals in analysis cell.



in a metal block to assure that they are uniformly affected by exterior temperature. The four spirals are heated a definite amount by passing current through them from the airplane's battery-generator system. Two of the spirals are exposed to the exhaust gas and two are exposed to "standard gas" (water vapor saturated air). A galvanometer (indicator) is connected across the two pairs of spirals. The schematic diagram, Fig. 2 shows this.

The spirals have equal resistance at the same temperature, and will remain in electrical balance as long as they are surrounded by gases of similar conductivity and are, consequently, at like temperatures. However, when the pair of "test" spirals is exposed to exhaust gases of different mixtures, their temperature will change accordingly and cause the Wheatstone Bridge to become unbalanced electrically. Whenever, then, the thermal conductivity of the exhaust gases deviates from that of the "standard" gas (water-vapor-saturated air) the bridge becomes unbalanced resulting in a deflection of the galvanometer pointer. The amount of pointer deflection varies to an extent comparable with the variation in the constituents of the gas. In this manner, it is possible to determine the fuel-air ratio directly.

Part II—Component Parts

The complete instrument consists of:

1. One or more analysis cells (one for each engine) usually mounted on the fire wall;

2. One indicator (containing a scale and pointer for each analysis cell) mounted on the instrument panel;

3. Electric leads for connecting the analysis cells to the indicator and to the airplane's battery-generator system;

4. Inconel steel sampling nipples, copper or stainless steel tubing, and rubber connectors for conducting the exhaust gas sample from the engine exhaust stack or collector ring through the analysis cell.

Fig. 3 shows the analysis cell and single-engine indicator of a Cambridge Fuel Mixture Indicator. Fig. 4 shows the indicator used on a four-engine installation.

The indicator consists of as many indicating units as there are analysis cells. Each indicating unit consists of a galvanometer (voltmeter movement) and a scale and pointer for indicating the fuel air ratio. Some types, as shown in Figs. 3 and 4, have scales bearing manifold pressure values as well as fuel air ratio markings. In addition, the indicator contains a lamp for illumination, and the necessary coils, plugs, sockets, etc. for making connections to other units of the assembly. The fuel air ratio scale reads from 0.110 at the left end (rich) to 0.066 at the right (lean). The mixture 0.077 is labeled "A" on the scale and represents electrical zero. Where a manifold pressure scale is used, it reads from 20" to 37" of mercury. The indicator also contains a ballast tube (resistor sealed in hydrogen) for main-

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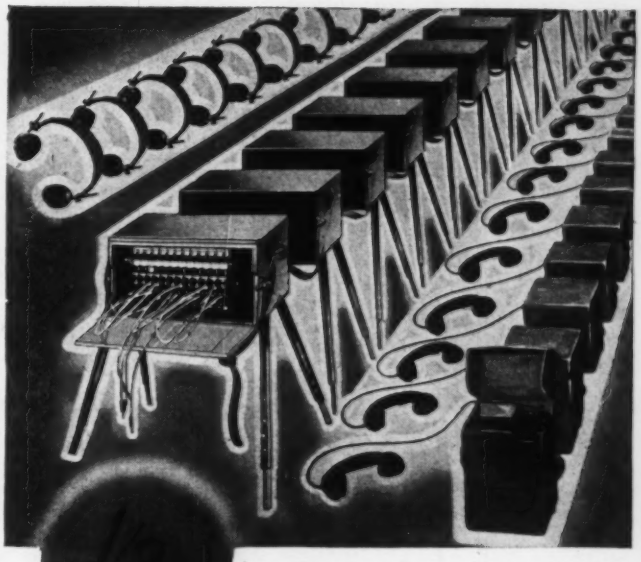

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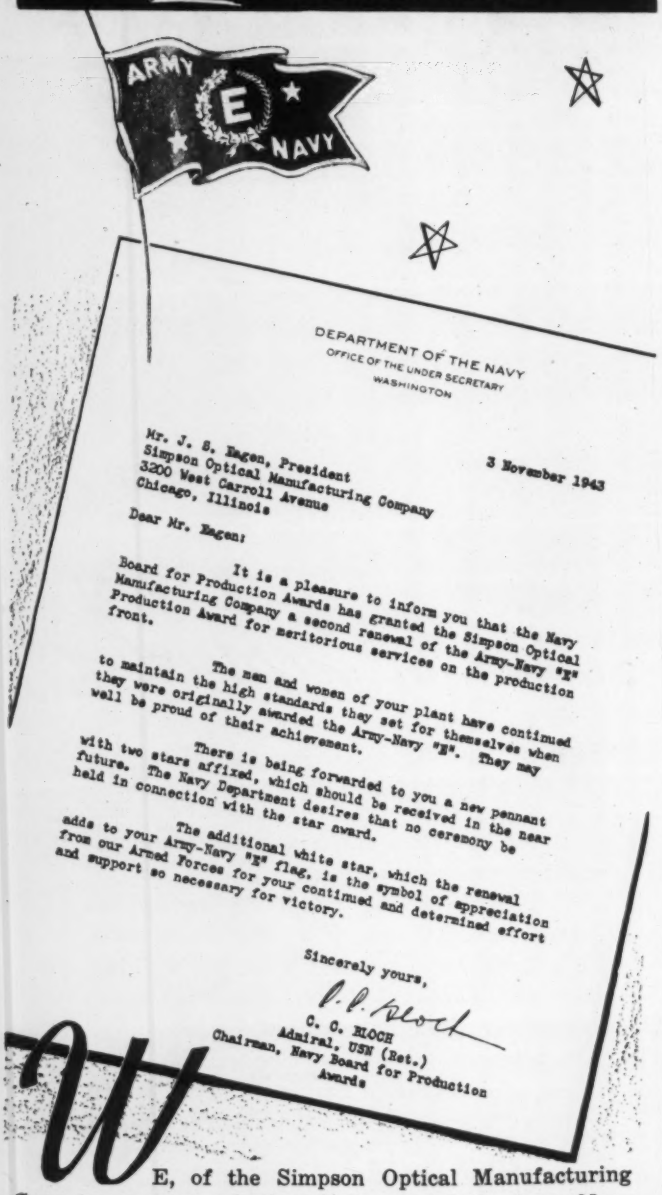
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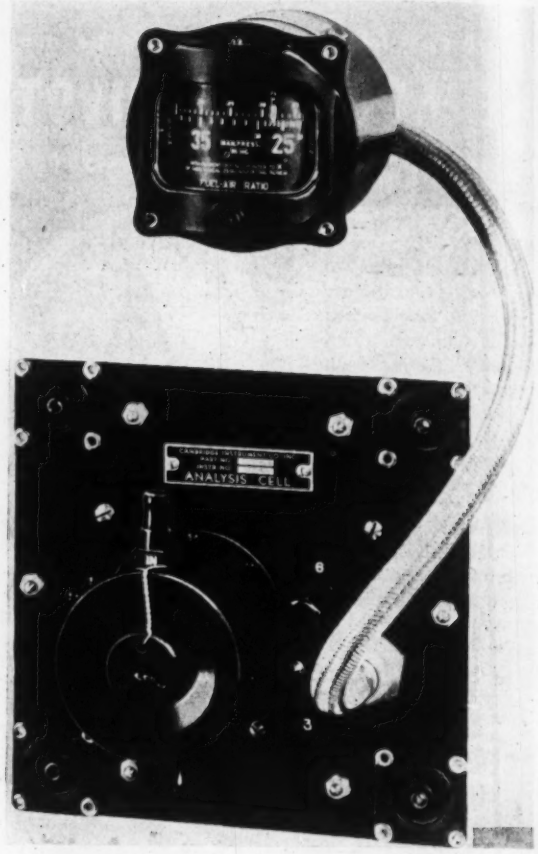

Fig. 3. Cambridge single-engine analysis cell and indicator.

taining a substantially constant current through the four platinum spirals in the analysis cells. The fuel mixture indicators manufactured by the Breeze and Englehardt companies have this ballast tube located in the analysis cell.

The analysis cell (there must be one for each engine) comprises a brass block containing the four platinum spirals. An inlet nipple is provided for connecting to the inlet sampling tube and a steel wool filter and filter chamber are incorporated to permit removal of carbon from the exhaust gas. The outlet nipple is connected to the outlet sampling tube. In some units a porcelain wick, which is filled with water, is included to saturate the air to which the pair of "standard" comparison spirals is exposed. In addition, necessary resistors, plugs and sockets are included.

(To be continued)

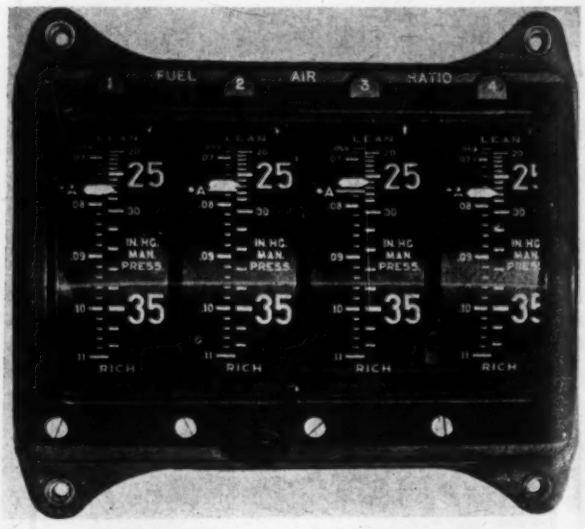

Fig. 4. Cambridge 4-engine Aero Mixture Indicator.

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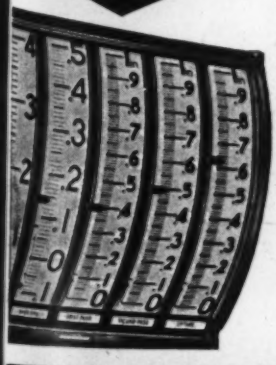

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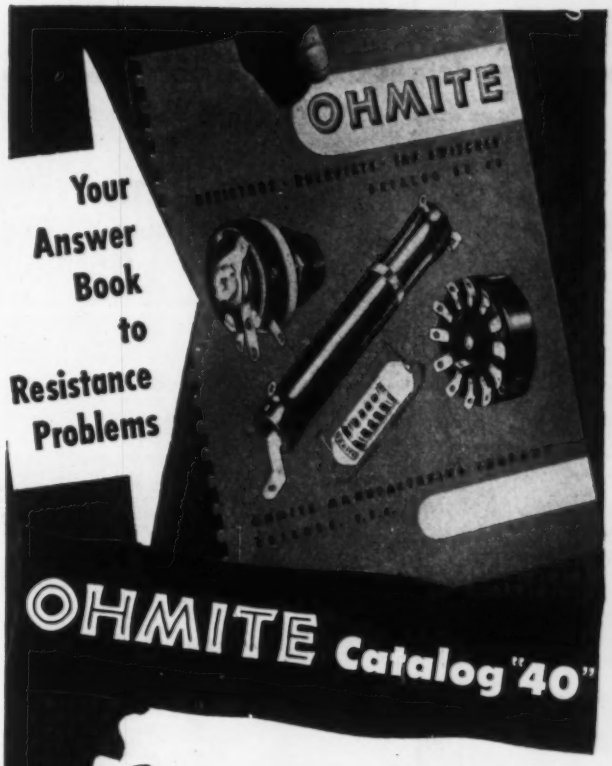

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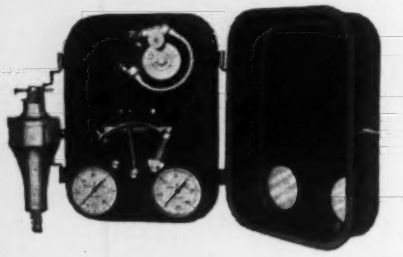

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More than just a satisfactory substitute for plates made out of war-vital metal... Herman PRECISION GRANITE Surface Plates are a *distinct improvement—definitely superior* in every respect. Cut from solid blocks of natural granite—far harder than any tools which will be used on them—they are absolutely warp-proof and remain accurate to 1/10,000 inch overall. Because they do not become charged with abrasives, even when used near grinding machinery, wear on tools is virtually eliminated. Both rust and corrosion-proof, they are practically indestructible. Already in nation-wide use in scores of important shops. Write today for full details on how Herman PRECISION GRANITE Surface Plates can increase production efficiency and economy in your shop.

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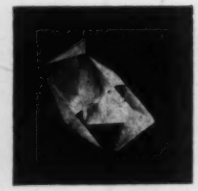
. . . *of high accuracy*



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Glendale makes optical units that completely meet the demands of the most exacting instrument makers. Our entire production is made to specification and we tolerate no less than the highest standards of precision. To obtain optical units for exacting use, call upon *Glendale* to make your requirements.

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Dependable Power for Blower Applications

. . . Oster Type C-2B Motor (1/100 H. P.) stands up in severe ambient temperatures

This specialized motor operates satisfactorily in a 90° ambient, for continuous duty. It is quality-built by the Oster organization, which for 15 years has been building fractional horsepower motors for use exclusively as original equipment on Oster motor-driven appliances. Ball-bearing equipped; built in an aluminum die-cast housing; 6, 12, 24, or 115 volts DC, 115 volts AC . . . You can depend on Oster motors to deliver creditable results that add to your own reputation for selecting sources wisely. Let us help you fit this or other Oster motors to your requirements.

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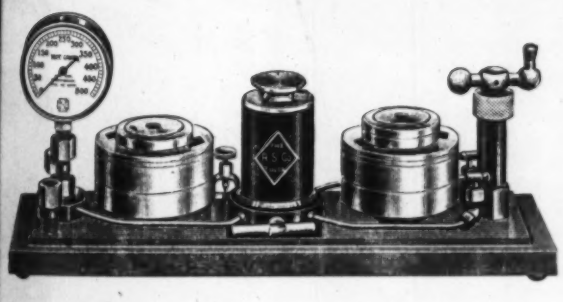

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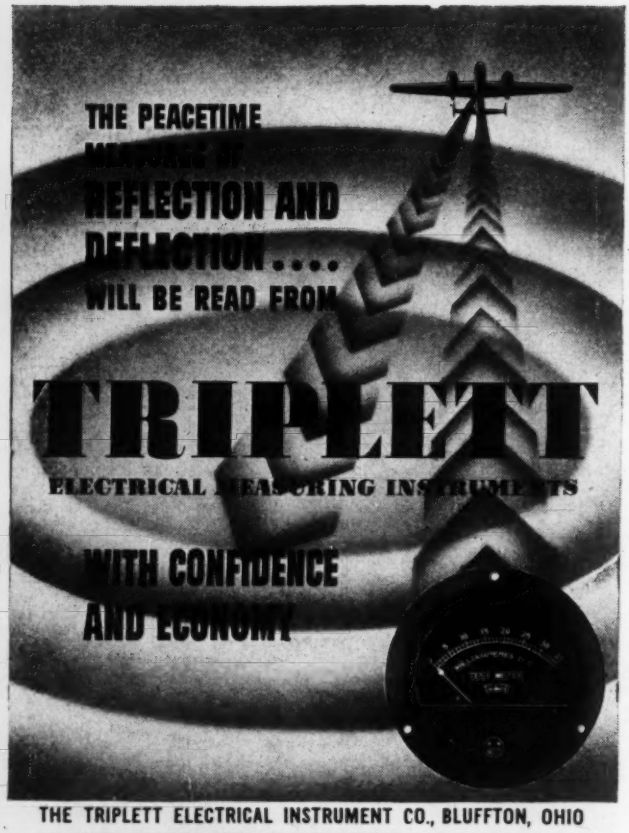

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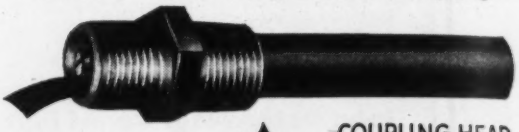

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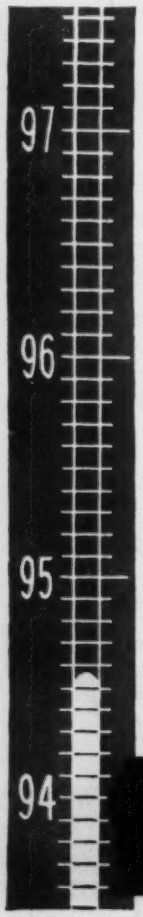

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. . . will give you exact information to prevent quality variations, spoilage or re-runs. Your inquiries on any such problems will be welcomed. Write for Blue Book 4 (Temperature Controls) or 5 (Thermometers and Hydrometers). H-B INSTRUMENT COMPANY, 2525 No. Broad St., Philadelphia 32, Pa.

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The Alnor Velometer is a versatile reading air velocity meter which gives instantaneous readings of the speed of air measured in feet per minute.

The Velometer is ideal for measuring duct velocities and pressures, velocities at grilles or registers. It offers the only convenient and satisfactory instrument for checking drafts, leaks around doors or windows or in ducts, velocities of ceiling outlets and similar air diffusers.

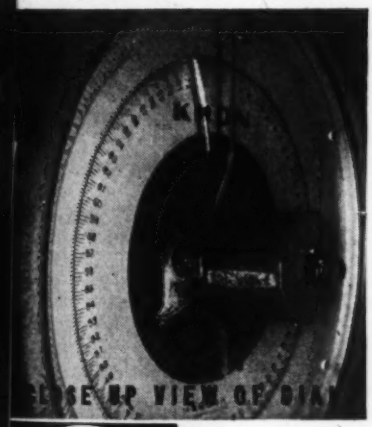
It is made in several standard ranges from 20 F.P.M. to 6000 F.P.M. and up to 3 inches static or total pressure. Special ranges available as low as 10 F.P.M. and up to 25,000 F.P.M. velocity and 20 inch pressure.

Anyone can use the Velometer. No mathematical calculations, no leveling—no timing.

Write for bulletin No. 2448-D

Illinois Testing Laboratories Inc.

142 West Hubbard Street Chicago, Illinois



"Magna-Pointer" held at zero before timing interval.

"Magna-Pointer" engages and moves with weigh pointer during interval.

"Magna-Pointer" instantly stalls at end of timed interval.

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Can be attached to the weigh pointer or detached and held stationary at any instant during a weighing operation, or force measurement without affecting the accuracy of the scale instrument.

Can be operated manually or by remote timer or switch gear.

Permits accurate "rate of flow" indication for timed intervals. It is a perfect automatic tare device for barrel, box or bag filling. It is invaluable for mixing chemicals or fluids.

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The MJL No. 163

The MJL No. 163 Rate-of-Flow Indicator Combines many features not hitherto available in differential pressure gauges:

1. A unique rupture-proof Bellows Unit takes the place of the mercury column commonly used in instruments of this type.
2. Instrument cannot be injured by excessive differential pressures.
3. Dial is easy to read at all times. Visibility is not affected by the condition of the fluid being metered.
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5. May be mounted at the most convenient location for ease in reading.
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Write for Illustrated Bulletin No. 163-1

MOREY & JONES, Ltd.

Industrial Instruments

922 South Hemlock St.

LOS ANGELES 21 CALIFORNIA

"Bomber Nose" Tester

Concluded from page 756

to the apparatus under test and plainly viewed by the project engineers. At 7½ miles, many things can happen to aircraft radio and electronic equipment, since apparatus of this type incorporates many delicate mechanisms. Low temperatures and pressures bring about changes in these delicate mechanisms which may cause current leakage, disabling electrical discharges known as "flashovers" and other failures which normally will not occur at low altitudes.

This chamber is cone-shaped, about four feet high and five feet in diameter at its base. It is just less than 1" thick and capable of withstanding tremendous shocks and pressures. Normally, before assembly on its bombing plane, holes are bored for the business ends of machine guns and heavier weapons. In RCA's adaptation into a stratosphere test chamber, the holes are omitted, thus enabling the engineers to make it air-tight. An air-tight seal is accomplished by fitting a heavy platform, arranged for mounting radio apparatus under test, with a ring of soft rubber. The test chamber is lowered until its

base rests on the rubber ring and, as it is evacuated, atmospheric pressure forces it down into the rubber ring and creates a perfect air seal.

The idea of turning a bomber nose into an altitude test chamber occurred simultaneously to several RCA engineers while they were observing the installation of radio apparatus in bombing planes at an aircraft plant. It seemed so simple at first to be absurd, but the engineers decided to try it anyhow. They put the idea up to Air Force officers and to executives of Rohm and Haas, all of whom agreed to coöperate in the venture. After initial tests were made it became a simple matter of engineering routine to design the circular platform and rubber seal ring and mounting arrangements for testing radio apparatus.

Test chambers previously in use were constructed of metal with heavy glass windows serving as portholes. RCA engineers say that lack of adequate visibility through these portholes frequently required shifting and remounting the apparatus under test to permit complete observation of results and each shift in mounting called for repeating the simulated altitude run at stratospheric pressures. These tests are made in a single operation by means of the all-plastic chambers. Thus, these bomber noses at RCA keep other bombers flying with equipment that functions despite the altitude or temperature.

"Supersensitive"

D. F. Hang at G-E tests a photoelectric recorder sensitive enough to record full scale a millionth of a millionth of a watt, as in studies of nerve action. It is being used by the Armed Forces.

Electronically-checked Powder Charges

OSCILLOGRAPHIC checking of powder charges for ballistic factors now contributes to the surpassing accuracy of our artillery fire on many fronts. Such checkup of each production run of powder is eliminating erstwhile errors in fire-control calculations caused by variations in the powder charges propelling the shells. Thus greater precision is possible in setting up intricate ballistic formulae. And this newly gained precision, coupled with the splendid training of American gun crews, is causing further discomfort and consternation for our enemies.

This American development in the field of powder testing is based on the use of a DuMont Type 235 cathode-ray oscillograph (Allen B. DuMont Laboratories, Inc., Passaic, N. J.). A powder sample is exploded in a strong sealed container. Voltages derived from that confined explosion by means of special primary elements are applied to the horizontal and vertical plate pairs of a cathode-ray tube through suitable amplifiers. This

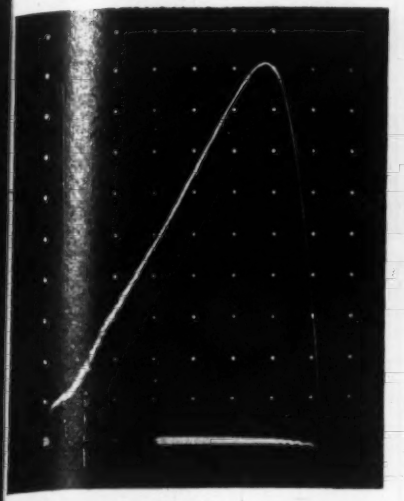


Fig. 1

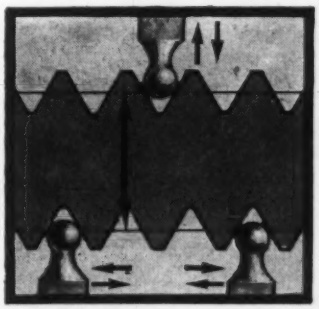
simultaneous deflection in perpendicular directions causes the beam to move in a path which plots a graph on the fluorescent screen. (See Fig. 1.) The oscillogram is photographically recorded and later analyzed.

Not only does the screen of the cathode-ray tube provide a qualitative indication but it is quantitatively calibrated by the application of a series of dots arranged in a matrix as shown in Fig. 1. Both graph and matrix are photographically recorded. Each luminous dot is positioned on the screen so that the horizontal or vertical distance between any two adjacent dots is a constant known factor. This matrix then serves as an accurate reference or coördinate system for the ballistic graph. This novel calibration method results in an accuracy which allows duplication of readings within 0.5%.

A 4 × 5″ reversible-back camera using cut film is mounted in front of the c.r.o. screen to record the visual graph. At eye level for the standing operator, the camera is critically focused on the tube screen by means of its ground-glass back.

Fig. 2

MODEL 45B-100. The upper, sensitive roller contact actuates the Dial Indicator.



MODEL 45B-80. The upper, sensitive ball contact actuates the Dial Indicator. Both lower ball anvils float sidewise independently to compensate for any variation in lead.

No conventional type of gage, whether ring gage or roller-type snap gage, can tell you so **definitely** and so **quickly** the degree of accuracy of a pitch diameter as these two types of Dial Indicator Gages. Neither depend upon the uncertain sense of touch.

The roller type tells more than the conventional roller snap gage because the sensitive upper roller contact, reveals on the Indicator, just **how much** and **where** the pitch diameter may be wrong. The ball type simulates the three-wire method, but is faster. It is accurate to a tenth of a thousandth. Either type is incorporated in the adjustable Dial Indicator Gage shown below. For details write—

TWO FULL COLOR FILMS
(With Sound)
No. 1 DIAL INDICATORS
No. 2 DIAL INDICATOR GAGES
20 minutes each. For instruction and training. For showing write

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FEDERAL
PRECISION MEASURING INSTRUMENTS

Since the oscillograph is usually operated by personnel not particularly familiar with the operation of complex electronic circuits, every effort has been made to reduce the number of controls to a minimum and to control automatically the sequence of events. Once the closed container or bomb has been charged and the circuit voltages adjusted, the operator need only actuate the plunger which automatically opens the camera shutter, turns on the cathode-ray beam, fires the powder charge, switches the input of the deflection amplifiers from bomb chamber to matrix generator, causes the equi-potential matrix to appear, turns off the electron beam, and then closes the camera shutter. The cut film can then be removed and developed, and the recording analyzed. Other event sequences which may be desirable for preliminary calibration are determined by a single selector switch.

Essentially, this DuMont Type 235 oscillograph consists of a 9″ diameter cathode-ray tube with short-persistence blue-fluorescent screen facilitating photographic recording; a 6000-volt power supply for the cathode-ray tube; stable high-gain d-c. deflection amplifiers; calibrating matrix generator; well-regulated low-voltage power supply; switching and control circuits; and the camera described above. These components are assembled in a movable rack assembly approximately 6 ft. high, 4 ft. wide by 2 ft. deep. Total weight is 720 lbs.

BAILEY METER CONTROL SYSTEM

The Mark of

Effective Control

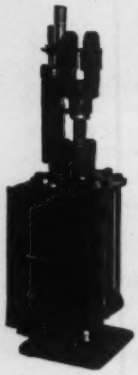
Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

C-3

BAILEY METER COMPANY

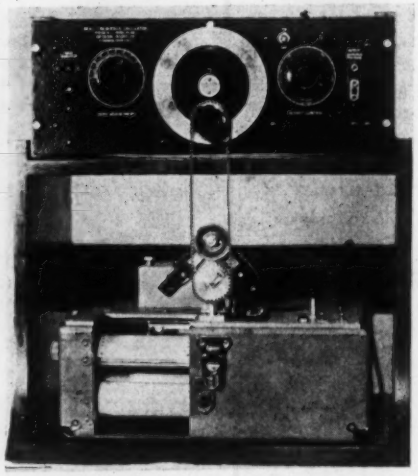
1041 Ivanhoe Rd., Cleveland, Ohio

The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Frequency Generator and Response Recorder Combination

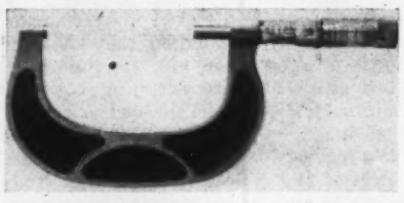
New apparatus illustrated is S.A. Automatic Frequency Response Recorder in combination with latest G. R. Audio Beat Frequency Oscillator. This measuring setup is



mainly a labor-saving device. Some of the main features are as follows: A complete automatic frequency run from 20 to 20,000 cycles covering a range of either 20, 40, or 60 db; recording forward and backward; it stops automatically at any pre-determined point of the frequency scale; the record (ink) is written on standard semi-log. paper. Recorder and oscillator can be used at any time as separate units since complicated connections are avoided. An unskilled operator can perform a multitude of complicated measurements of electro-acoustical apparatus which otherwise would require engineering skill and a great amount of time.—*Sound Apparatus Company, 150 West 46th St., New York 19, N. Y.*

Micrometers

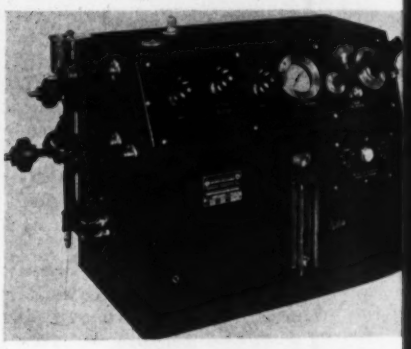
Announcement is made that henceforth all "Reed" micrometers in the 1", 2" and 3" sizes will be furnished with a vernier enabling quick and easy readings to 1/10000".



There will be no extra charge for this added feature. Illustrated is new "Reed" 2-3" micrometer showing the "tenths" vernier.—*George Scherr Co., 128 Lafayette St., New York 13, N. Y.*

Refractometer for Analyzing Liquid While It Flows in Pipe-line Under Pressure

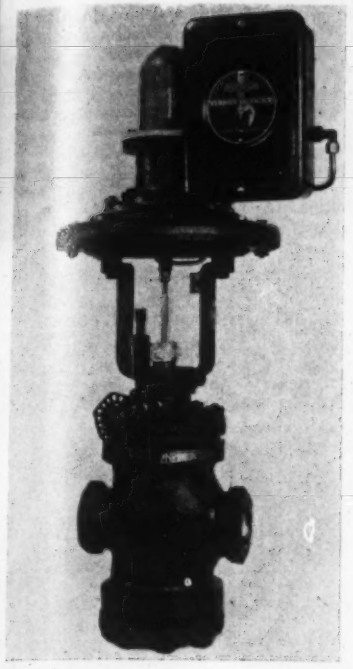
Engaged in continuous production of butadiene, Shell Development Co., Emeryville, Calif., faced problem of determining purity of products flowing through a processing pipe-line. Since continuous production makes it impractical to collect samples for removal to a testing laboratory and since no commercial instrument for *in-situ* analysis was available, Shell technical staff had to devise a new instrument. They found a solution of this problem in the measurement of the physical factor of refractive index as an indication of purity of butadiene; designed an instrument utilizing this principle; permitted undersigned company to manufacture and market the "Shell Continuous-flow Pressure-type Refractometer,"



based on original Shell design, but incorporating structural modifications and refinements. Butadiene under atmospheric pressure boils at 19°C., so that refractometric readings must be made either under pressure or at decreased temperature. With this new instrument, readings are taken at the pressure at which butadiene is produced. Instrument comprises a refractometer, with dipping prism mounted in a pressure cell through which the liquid, whose index of refraction is to be measured, flows continuously under the pressure existing in the process flow-line, while being maintained at constant temperature. Both pressure and temperature maintained within the instrument are adjustable to meet individual installation requirements and applications to various liquids. — *Precision Scientific Co., 1750 N. Sprinffield Ave., Chicago 47, Ill.*

Positioner for Diaphragm-motor Valves

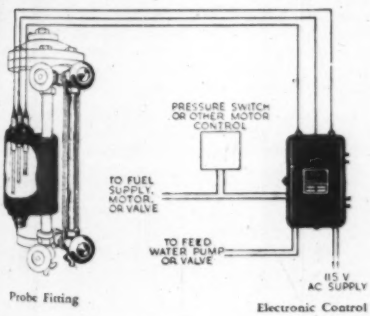
New capabilities, as well as new convenience and sturdiness, are said to be featured in new model of "Vernier Valvactor," a micro-positioner for pneumatic-motor valves. It assures dependable valve response where operating conditions would otherwise make response slow or uncertain. It is actuated by air pressure changes a



slight as equivalent of ½" of water, and can compel valve stem movements as small as 0.001". New construction involves a completely different arrangement of actuating elements. New ease and range of adjustment, especially for duplexing and sequencing, and snap action, for relay service or step sequencing of valves or damper motors, are provided by new zero and range adjustments. New ease of reversal is provided, without change of parts or piping. Flexure type bearings, in place of pivots, eliminate effects of mechanical vibration, without impairment of sensitivity. Metal case is heavier than that of old models. *The Foxboro Co., Foxboro, Mass.*

Boiler Feedwater Regulator

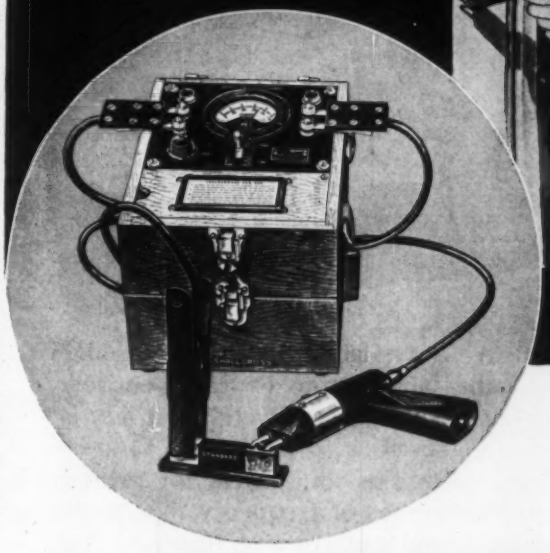
New "Fireye Electronic Feedwater Controls Series P156N" is designed for maintaining constant boilerwater levels automatically, and for guarding against low-water hazards, is "guaranteed for an unlimited service-free life." For automatic feedwater pump control and low-water protection, it is used with "Probe Fitting Type H53," as shown in illustration. Probe fitting may be mounted parallel to the water column or directly on boiler. Three probes within "Type H53" mark boiler feed-water pump on and off levels and a low-water danger point. Top and middle probes determine the high and low levels at which the boiler feed-water pump is turned off and on. Lowest probe defines the danger point below which boiler water must not fall. Should water drop below this safety probe, control shuts off fuel supply and sounds an alarm. Types are available also for auto-


PRESSURE SWITCH OR OTHER MOTOR CONTROL
TO FUEL SUPPLY, MOTOR, OR VALVE
TO FEED WATER PUMP OR VALVE
115 V. AC. SUPPLY
Probe Fitting
Electronic Control

Typical FIREYE Installation For Automatic Boiler Feedwater Control And Low-Level Safeguard

New! LOW-RESISTANCE TEST SETS

(BOND TESTERS)



The modern way to test bond or contact resistance down to 0.0001 ohm.

Fast – Accurate – Easy to Use

The new Shallcross Low-Resistance Test Sets, Types 645 (Army range) and 653 (Navy range), include all of the features of the Shallcross Milliohmmeter and Aero Gun Models while providing greater portability, ease and speed of operation.

The Tester itself is supported conveniently in front of the operator by means of adjustable shoulder straps. Measurements as low as .0001 ohm are made, simply by attaching the fixed clamp to one side of the bonded surface, and touching the hardened points of the Pistol Grip Exploring Probe to the other side. The weight of the Pistol Grip Exploring Probe is reduced to a minimum by incorporating the meters, batteries, etc. in the suspended Tester cabinet.

In addition to their widespread use in testing aircraft bonding, these Shallcross Test Sets are unexcelled for testing railroad bonds, radio equipment, contact resistance of relays, circuit breakers, switches, and various others. They make bar-to-bar resistance measurements on commutators as simple as taking a voltmeter reading.

The two new models are similar, except that Type 645 (Army range) is 0.005 and 0.5 full scale, whereas Type 643 (Navy Range) is 0.003 and 0.3 ohms full scale.

WRITE FOR "BOND TESTER" CATALOG

A copy of the Shallcross Low-Resistance Test Set Catalog describing these and other Shallcross models in full detail will gladly be sent on request. Write for Catalog

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AVAILABLE IN SMALL PANEL BOARD MOUNTING SIZES

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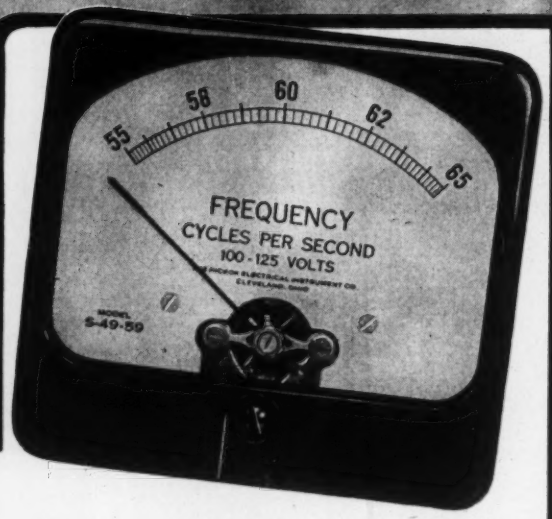
LOW TEMPERATURE ERROR

LOW POWER CONSUMPTION



This compact instrument is available in 4″ rectangular panel mounting case—other sizes up to 6″ case—entirely self-contained—*no external reactor* . . . . Overall accuracy is better than .2 of a cycle in 60 cycles . . . . Made with 55 to 65 cycle reading but also available in 59-61 cycle for greater reading accuracy and other ranges of frequency . . . . Indication by pointer and graduated scale, easy to read . . . . Vibration-proof and shock-proof . . . . Damping can be adjusted to suit extreme conditions of frequency variation . . . . Instrument is accurate within ambient temperature range from minus 10 to plus 40 degrees C . . . . Power consumption only 0.8 watts at 115 volts.

Write for illustrated booklet on this meter.

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HAND TACHOMETER
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3000—12000 RPM
Rugged • Reliable • Continuously Indicating Type
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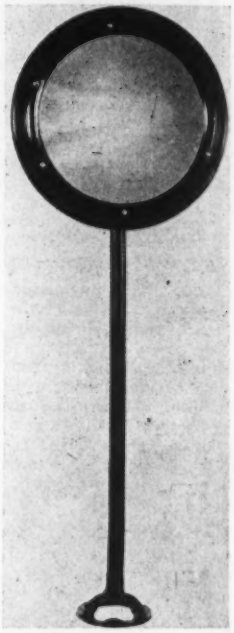
27 PARK PLACE NEW YORK, N. Y.

matic pump control only, or for low-level protection only. New feedwater controls are supplied as standard for boiler pressures to 300 lbs./in.² and for operation from a supply of 115 or 230 volts a.c. 60 cycles. Equipment governs solenoid valves, small-horsepower pump motors, or pump motor magnetic starters. Probe housing is furnished in either cast or malleable iron, and the electronic control in a weather-proof pressed steel housing, both finished in green crystal.—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Magnifying Mirror

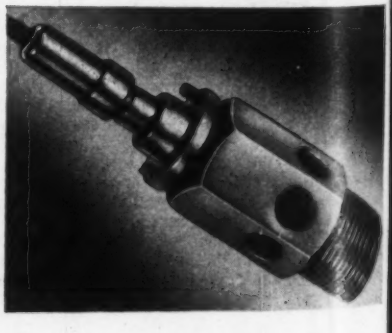
New "No. 7-11" magnifying mirror has a 7½″ diam. head (5⅞″ mirror diam.) with a 15″ flexible tube and bracket. Mirror mounting at back is on an L arm; base has



three holes for mounting by means of bolts, wood screws or machine screws. Instrumentation uses are said to include "countless places where you need to watch a dial at a point not otherwise visible." Focal length is such that, for average observer, mirror should be placed 10″ to 12″ from instrument pointer or other object to be reflected. Shipment about two weeks from receipt of orders. —*Larrimore Sales Co., P. O. Box 1234, St. Louis 1, Mo.*

Pressure Pick-up

New "No. 3000 B" pick-up embodies improvements over old models. It has a new bayonet type socket which provides quick, reliable contact between connection cable and pick-up. Adaptor adjustments are much simpler because two set-screws replace older type hexagonal nut. New construction permits easy installation and removal from engine with an ordinary socket wrench. Pick-up coil has special impregnation that withstands continuous operating temperatures of 350° F. It is said to be engineered



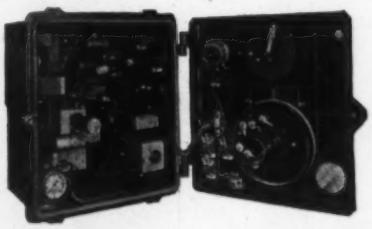
to provide quick replacement of either diaphragm or coil for extra economical operation and long life. It operates at constant polarity. It is designed for use in studies of detonation conditions in internal combustion engines, and for compression conditions in pumps and other devices where there are variations in pressure. It may be used also to actuate a cathode-ray oscillograph or maker's "Knock-intensity Indicator" for rating of engine fuels.—*Electro Products Laboratories, 549 West Randolph St., Chicago 6, Ill.*

Preliminary Test Bomb

New "Preliminary Test Bomb" is intended for making preliminary tests of chemical reactions at high pressures, with safety and convenience, at low cost. As normally supplied the pressure seal is made by a copper gasket (totally enclosed for safety) between the head and the mouth of the bomb. Screwed into a standard "Aminco Superpressure" opening for ¼" o. d. tubing in the head is a needle valve with side outlet for the same type of construction. No opening is normally supplied in bottom of bomb. Where it is desired to maintain flow within the chamber, bomb can be supplied with a standard "Aminco" connection for ¼" o. d. tubing in bottom, together with a plug to seal bottom opening when not in use. Standard construction is of high-strength steel. Each bomb is tested individually to 15,000 lbs./in.² and is intended for safe operation at a maximum internal pressure of 10,000 lbs./in.². Calculated bursting pressure is over 40,000 lbs./in.². The valve in the head permits charging at pressures as high as 5000 lbs./in.² and will seal contents of bomb up to the full working pressure of 10,000 lbs./in.².—*American Instrument Co., Silver Spring, Md.*

Electro-pneumatic Relay Type Controller

New "Celectray Pneumatic Indicating Controller" is annouced as the first instrument of this type that does not employ a motor or other continuously-moving parts.



It is said to incorporate unique features, among them: no motor, continuous action, no measurable dead zone, highest sensitivity and adjustment to low sensitivity, no mechanical connection between galvanometer and pneumatic circuit, no flapper, simple load error adjustment (manual reset). Original "Celectray" Controller with its mirror galvanometer and photoelectric amplifier (see *Instruments*, March 1934, pages 58-59; Nov. 1934, page 245; Apr. 1937, pages 95-96; Dec. 1937, page 298; Dec. 1941, page 388), is here combined with a pneumatic follow-up without impairment of any of its characteristics. Controlled-air pressure is precisely and stably controlled to provide utmost in performance according to inherent possibilities or ordinary throttling control with manual reset or with automatic reset and/or maker's "quick response." On-and-off or open-and-shut con-

Your ATMOSPHERIC TESTING PROBLEMS

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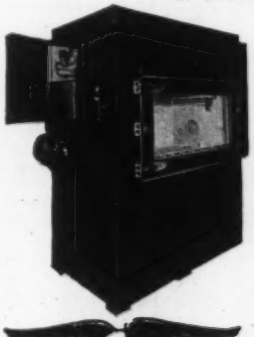
Many manufacturers present American Coils Company with difficult testing problems. A typical problem solved by Amcoil was as follows:

TEMPERATURE—The product had to withstand a temperature drop of from room temperature to minus 95° F. in 105 minutes. *Amcoil did it in 90 minutes.* It then had to come back to room temperature in 35 minutes. *Amcoil did it in 30 minutes.*

From room temperature it had to rise to 160° F. in 35 minutes. *Amcoil did it in 30 minutes.*

HUMIDITY—This same product had to operate under the following conditions:

1. 140° F. at 95% relative humidity for ½ hour.
2. 140° F. at 30% relative humidity for 1 hour, change to 100° F. and 20% relative humidity and hold for ½ hour.
3. Return to 95% relative humidity at 100° F. and hold for ½ hour.
4. Hold at 75° F. and 50% relative humidity for 18 hours.



Model RTC1-AA with humidity attachment, occupying a floor space of only 42" deep x 71" wide x 91½" high, with net interior dimensions of 52" long x 30" deep x 27½" high solved this problem with ease. A cross-ambient control prevents overshooting at humidities and temperatures close to actual room conditions.

Amcoil manufactures a complete line of atmospheric and stratospheric testing equipment to meet your requirements. Special testing problems not covered by our regular line are handled individually by Amcoil's war-seasoned engineers.

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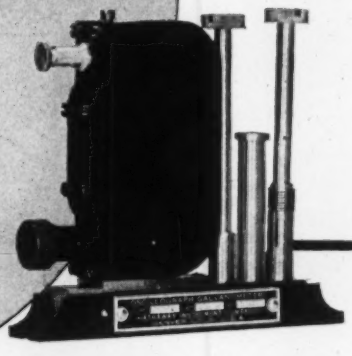


HATHAWAY GALVANOMETERS
(for oscillographs)

('heart' of a wide variety of recording instruments) have reached such perfection that galvanometers are no longer a limiting factor in the operation of the whole instrument.

Type OA-2, illustrated, is a bifilar galvanometer for applications requiring high-frequency response, low power input, and ability to function under extreme vibration. Its precision optical elements guarantees records of highest quality. Moving element is a single loop of fine metallic ribbon, tightly stretched between the poles of a powerful permanent magnet. Recommended for recording frequencies above 250 cycles. Can be supplied with sensitivity as high as 50 millimeters per milliampere at 1 meter, or natural frequency as high as 10,000 cycles per second! Other types of oscillograph galvanometers are available for higher sensitivities at lower frequencies.

Write for factual bulletin

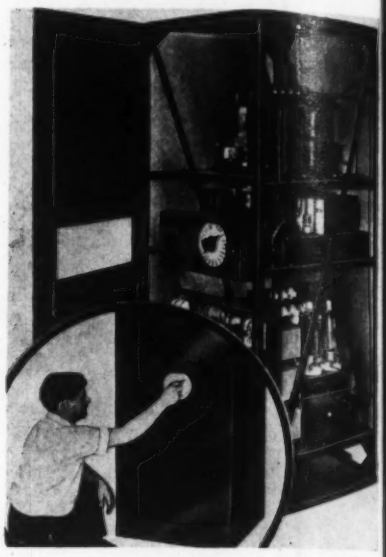
Hathaway INSTRUMENTS

1315 SO. CLARKSON—DENVER, COLO.

trol is available in two models, high sensitivity, non-adjustable throttling or on-and-off without throttling. Measuring circuit, including galvanometer and photoelectric system, is similar to that of standard "Celectray" Controller, but in place of that controller's relay there has been substituted a magnetic air-valve which acts as an amplifier and converter from electric to pneumatic operation. Light beam "follow-up" flag is moved back and forth by changes of air pressure in bellows of "follow-up" assembly unless the sensitivity-adjusting arm is turned to the highest sensitivity on its scale. With this adjustment, throttling range is zero, flag stands still as control pressure varies and controller acts as an on-and-off or open-and-shut controller, opening or closing the valve to its limits for small changes in temperature, for example. Now as temperature varies, light image moves across controlling edge of flag and more or less light reaches phototube. More light on phototube causes more current to flow through magnetic air valve. This in turn draws in armature, moving orifice tongue closer to orifice in block and raising controlled air pressure. Less light on phototube thus lowers controlled air pressure by decreasing current to magnetic air valve. If sensitivity is lowered by moving adjustment-arm to a lower value on scale, then flag will follow light beam as it moves back and forth with changes of temperature. Flag will follow to limits of throttling zone as determined by position of arm. Manufacturer claims that this instrument is least affected by process lag, has nearest approach to ideal performance, fastest response, is stable at smaller throttling zones, not affected by long leads, simple in operation and adjustment, vibration-proof.—*C. J. Tagliabue Mfg. Co., 550 Park Ave., Brooklyn 5, N. Y.*

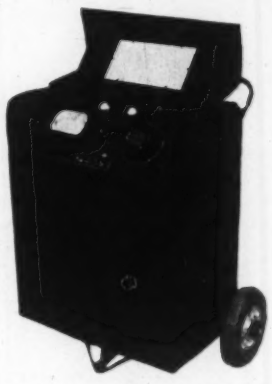
Variable Frequency Generator

New "CML 1400" variable frequency generator is said to have been developed to fill the need for a versatile source of power, especially for engineers requiring test power at various loads through a wide frequency range. Laboratories and manufacturers in the electronics field are said to find this electronic generator capable of delivering power with good regulation and waveform over a frequency range of 300 to 3500 cycles. "CML 1400" is said to be especially valuable where Government specifications call for complete tests on the production line through a wide range of power frequencies. New generator includes a variable-frequency oscillator, followed by several driver stages. Output stage employs a pair of 833-A tubes in Class B. Because of the high impedance of such a power source, the regulation of generators of this type is quite poor, ordinarily. This difficulty is said to be overcome by means of a special control circuit which maintains output voltage at a substantially constant level from no load to full load. Power output of "CML 1400" is 1400 watts at 120 volts r.m.s., with a load of unity power factor.—*Communication Measurements Laboratory, 120-24 Greenwich St., New York City.*



Insulation Breakdown Tester

New "Hypot" insulation breakdown testing instrument is mounted on rubber-tired wheels, has a reel on the back for holding the high-voltage test leads as well as the 115-volt 60-cycle input cord and plug and grounding lead. A hinged cover encloses and protects the control and instrument panel. Two large pilot lights are mounted at top center of panel. The white one indicates that the "Hypot" has been energized; the



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Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile we would welcome the opportunity of working with you in developing your post-war designs.

Remember, Chelsea has been making special movements for recording instruments for many years.

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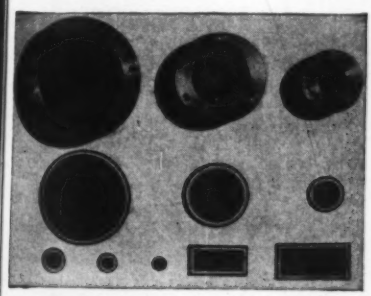

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MANOMETERS

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Trimount Inclined Gauge (accuracy 1/100" water), 60" water manometer and 20" mercury manometer on test bench for checking small air jets at Bendix Aviation plant

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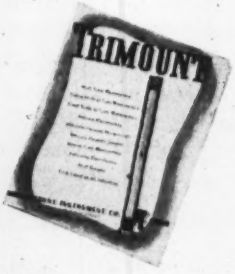
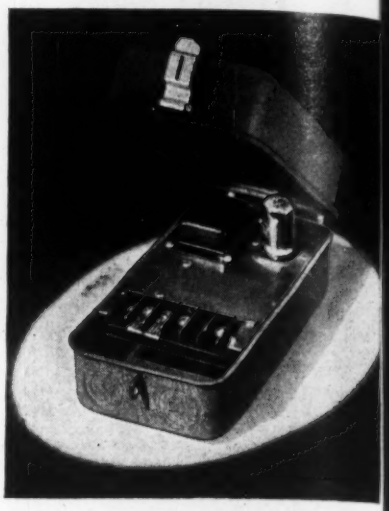


TRIMOUNT *Red Line* **MANOMETERS**

red one indicates that the high-voltage test leads are energized. Below pilot lights is the circuit breaker control, arranged so as to kick out when current flowing in high-voltage side of breaker exceeds 500 milliamps (in accordance with A.I.E.E. specifications). Below circuit breaker is "Burn and Test" switch: In test position, instrument makes all tests in accordance with A.I.E.E. specifications that with 500 milliamps in high-voltage circuit the voltage applied will be within ±20% of initial indicated value. "Hypot" regulation is better than 14%. Voltage control is accomplished by means of a Transtat variable voltage control, from zero to a maximum of 3000 volts in the secondary. When switch is in "Burn" position it cuts in automatic regulation whereby voltage applied across specimen under test reaches a value necessary to provide a continuous burn so long as the current is applied to specimen. This "Burn" feature is exclusive with Models No. 406 and 407 testers. Capacity of equipment, when supplied with the "Burn" test is 3 kva; when supplied without, it is 1½ kva. Test leads are supplied in several lengths dependent on model selected. In every case, they are 25,000-volt X-ray cable; high-voltage handles are of hard rubber, with flash rings to protect operator's hands. Removable tips are of adequate size and capacity. In its entire construction, instrument is said to have been designed to withstand all types of service including railroad yard and large industrial plant service. Electrically, every conceivable protection to operator has been provided. All internal switching is done on the grounded, or low-voltage side. Dimensions: 18" deep, 23" wide, 29" high; weight 200 lbs. Instrument is furnished complete and ready for operation.—*Associated Research, Inc., 231 South Green St., Chicago 7, Ill.*

Liquid or Conducting-solid Level Controller

New level controller maintains (or keeps within desired limits) level of any liquid or electrically-conducting solid within an open or closed tank, bin, hopper or other con-



tainer. It signals high and low levels or can be installed to operate solenoid- or motor-driven valves, pumps, etc. Controller is non-mechanical, utilizes electronic principles, has no moving parts and is claimed to have no chemical or other effect on liquids or solids being controlled. It can be installed in evaporators, freezers, boilers or other containers involving extreme temperatures; and can be used for controlling levels of metal chips, acids, brines, chemicals, oil, water, etc. Various combinations of single- and double-electrode installations are available.—*Trimunt Instrument Co., 37 W. Van Buren St., Chicago 5, Ill.*

Angle Computer

New "Model C" Angle Computer is specially designed for precision shop instruments involving vertical, horizontal and related angles. Protractor and vernier on

Fig. 1

this unit are calibrated to one minute of arc. Instrument affords two working positions, from either of which the work can be rotated a complete revolution. For example, an operator laying out a piece of work attached to the face plate in the horizontal position (Fig. 1) is able to scribe with his height gage the horizontal and related angular lines. Then, to get cross or 90° lines, he simply lays "Model C" in the vertical position (Fig. 2). If the job at hand must be laid out or checked in seconds, it usually is an easy matter to attach the

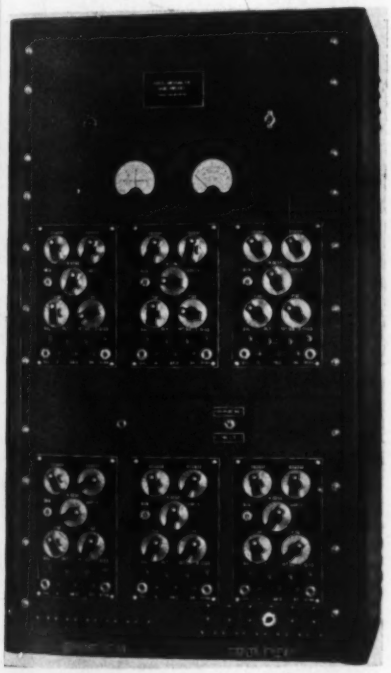
sine bar to the job already set up. (Where the third, or radial, angle is involved. Studler Model A or Model B should be used.) Face plate of Model C Angle Computer is 10" in diameter and 1" thick. Interchangeable Surface Plate is 5" × 10" × 5/8". A fine-grade cast-iron alloy, heat treated, is used in the body; machine steel is used for

Fig. 2

the spindle. Brake shoes are cast-iron and fixed in place and machined at the same time as the main bearing is bored, to assure perfect alignment so that, when brake is applied, work is not distorted or moved.—*The Angle Computer Co., 5720 Melrose Ave., Los Angeles 38, Calif.*

Amplifier-analyzer for Strain-measuring Systems

New "Model 2 Strain Gage Amplifier-Analyzer" is used to analyze and indicate (on a recording oscillograph) strains in mechanical members such as railroad rails,



beams, and similar structures. Instrument amplifying units featuring individual master bridge circuits. This makes it possible to indicate the strains produced on structural members by six individual pickups. All outputs and inputs are available from front-of-panel and each amplifying unit is removable from front-of-panel by removal of four panel screws. This makes possible convenient field calibration checks or service. Instrument has a built-in ten-tube regulated power supply holding plate voltage and filament voltage within ± 1%. A d-c. voltmeter is connected in circuit at all times and a zero-center milliammeter is used with a patch cord for initial balance of output plate current before recording oscillograph is used. Each strain gage amplifying unit contains six tubes and features a chromium-plated chassis and metal parts to resist corrosion in the field. All adjustments on each amplifying unit can be locked by dial thumb-screw locks to prevent change of calibration when instrument is exposed to vibration. D-c. output on each amplifier is 20 ma. linear over whole scale within 1%. Units may be used with any standard recording system. Frequency response of each unit is linear within 0.1% from 0 to 40 kc. Gain of each unit is 90 db. Instrument is 36" high, 20" wide, 18" deep, weighs 150 pounds, operates on 115-volt a-c. supply.—*Televiso Products, Inc., 6533 No. Olmstead, Chicago 31, Ill.*

The PALMER Thermometer works silently, without glamour, because it was built for long service, guaranteed accuracy and to be easy to read.

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INDUSTRIAL, LABORATORY, DIAL & RECORDING THERMOMETERS

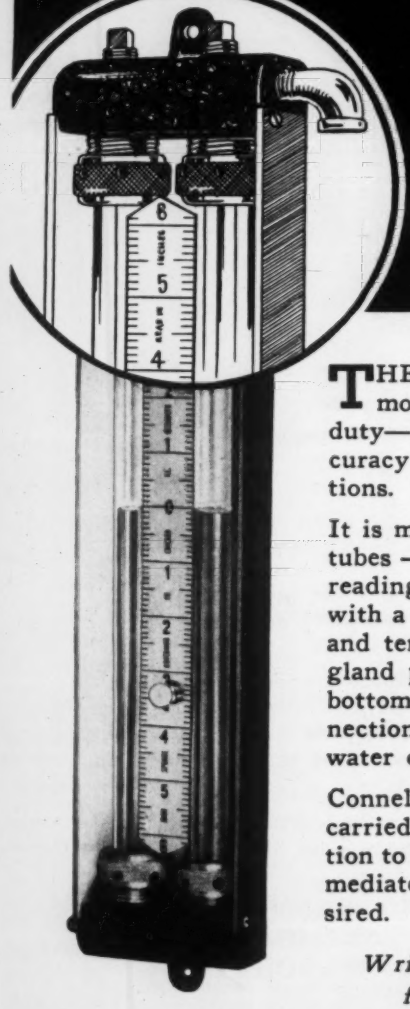
2511 Norwood Ave., Cincinnati, Norwood, O.—Canadian Plant: King & George Sts., Toronto

Insulation-resistance Indicator

New insulation-resistance indicator measures resistance of insulation in apparatus during manufacture, thus revealing imperfections before product leaves factory, is also desirable for checking condition of insulation of apparatus in service, and for use in laboratory for rapidly testing production or experimental samples of insulating material. New tester can be used wherever 115-volt, 60-cycle current is available. It comprises a conventional electronic rectifier, a Thyrite bridge circuit and an electronic-tube voltmeter. It is available in two types: one has a scale calibrated from 1 to 50 megohms and measures resistance at 500 volts d.c.; the other type has a 0 to 20,000-megohm total range and measures resistance over four different resistance intervals—from 0-5 megohms at 0-250 volts

Connelly EXTRA HEAVY DUTY Manometers

FOR PERMANENT MOUNTING



THE New Connelly Manometer, model 3400—built for extra heavy duty—can be depended upon for accuracy and long life under all conditions.

It is made with large bore, clear glass tubes — 3/4" in diameter — for easier reading even at a distance. Supplied with a scale graduated either in inches and tenths or in metric measure. It is gland packed, with drain plugs at the bottom and is fitted for 1/8" pipe connections. Made for use with either water or special anti-freeze solution.

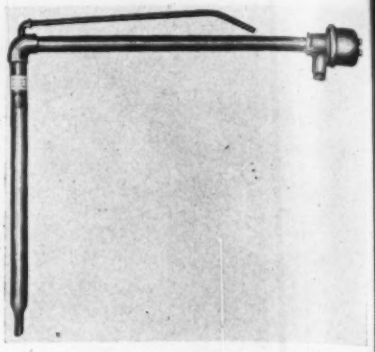
Connelly Model 3400 Manometers are carried in stock in five sizes. In addition to these stock sizes, larger or intermediate sizes can be supplied if desired.

Write today for bulletin giving further details and prices.

CONNELLY IRON SPONGE & GOVERNOR CO. CHICAGO, ILL. — ELIZABETH, N. J.

Thermocouple for Use in Liquid Bath Furnaces

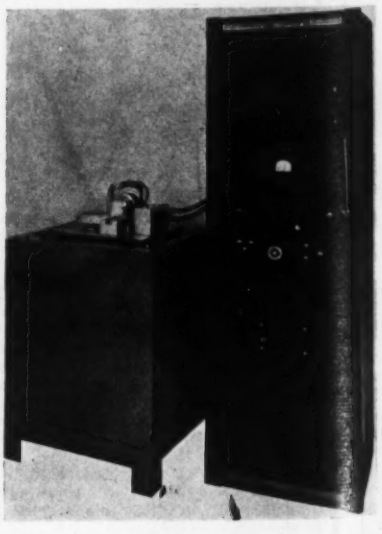
New "Vent-Type Thermocouple" is said to be a new type of assembly eliminating the collection of gases and reducing contamination to a minimum. Vent at top



permits gas escape and, by artificial circulation, admits right amount of pure air to take its place. (In some cases, when convenient, an air connection may be made with blower and an extremely small amount of air may be circulated through the tube. Too much air may alter thermocouple reading; but a small amount of air will remove contaminating gases without affecting reading.) One of chief difficulties experienced in obtaining satisfactory life of tubes and thermocouples used in liquid baths such as cyanide and salts is contamination of thermocouple by gases which collect in the protecting tube. It is said that new "Vent-Type Thermocouple" makes it possible to increase thermocouple life and efficiency by two or three times.—*Claud S. Gordon Co., 3000 S. Wallace St., Chicago, Ill.*

High-speed Balancing Machines

Undersigned company announces acquisition of right to manufacture and market new type of high-speed balancing machines developed under direction of William Hovgaard, Professor Emeritus of M. I. T., and introduced by Gyro-Balance Corp. under trade name of "Electrodynascope." New machines are said to differ from conventional ones in that they directly measure the added alternating bearing forces exerted by unbalance of rotor rather than tangible displacement of balancing parts. Alternating unbalance forces are transmitted by a practically rigid platform to quartz crystals producing piezoelectric potentials which are magnified by vacuum-tube amplifiers and made visible on the screen of a cathode-ray oscillograph. Magnitude of unbalance ulti-



d.c. and 5-200, 50-2000 and 500-20,000 megohms at 500 volts d.c., range selection being made by means of a panel-mounted rotary switch. *Operation*: measuring leads from instrument are connected to apparatus or material to be tested. Scale-range selector switch is turned to lowest range, and power switch is turned on. If necessary, selector switch is turned to successively higher ranges until pointer is in center portion of illuminated scale. Resistance of the material under test is read directly in megohms. Test voltage is regulated to 500 volts d.c. by Thyrite bridge, even though 60-cycle line voltage is fluctuating. Instrument is economical to operate. Cover of portable walnut case may be removed so that instrument can be placed on a shelf or stand in full view of operator. Well-illuminated dial permits scales to be read easily even in poorly-lighted locations.—*Special Products Div., General Electric Co., Schenectady, N. Y.*

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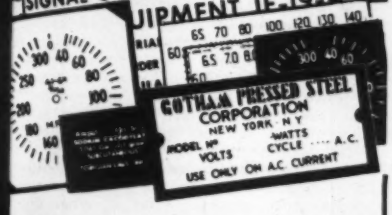

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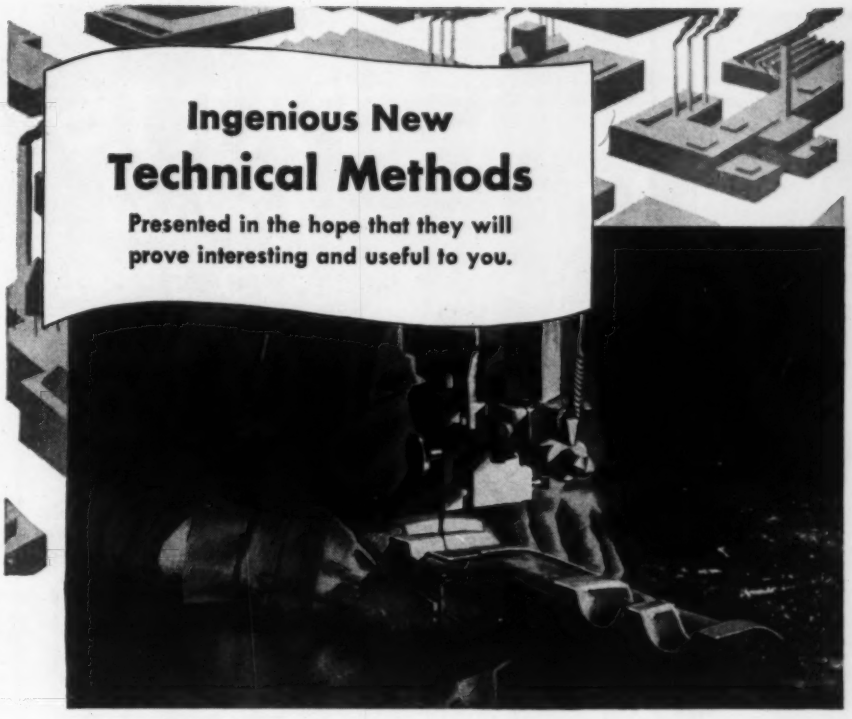

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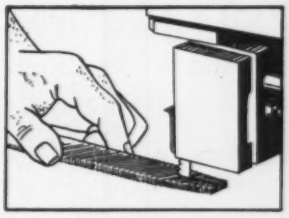
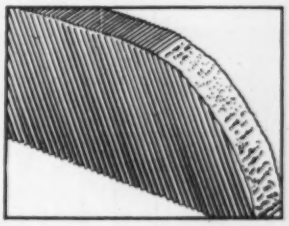
You can get complete information about this method from Bell Aircraft Corporation, Buffalo, New York.

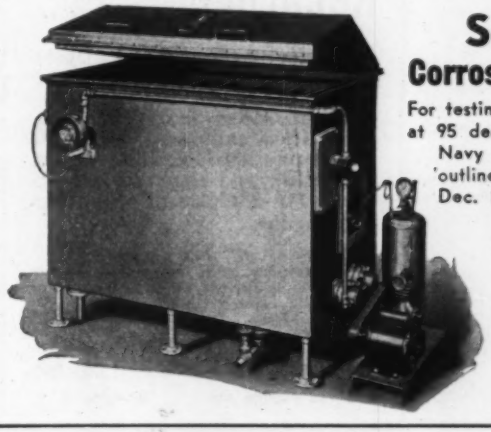


Proof of ability of new method to cut hard materials is demonstrated by operator cutting a file.



The temper of curve cut section shown above is unaffected.

X-60



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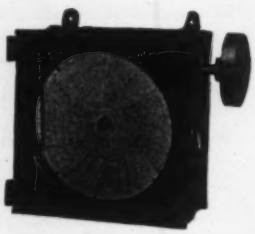

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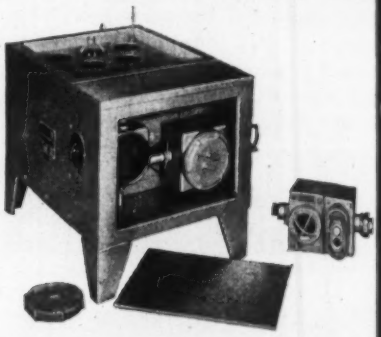
mately expressed in ounce-inches or depth of drilled or milled holes is indicated as a sine wave pattern, representing magnitude and location of unbalance. Since centrifugal forces are measured instead of displacements caused by such forces, and since the rotor is mounted on rigid supports having a natural frequency considerably above the balancing speed, inertia forces are said to be negligible and indications are said to be independent of weight of rotor. Standard models up to 75-lb. rotor weight for speeds up to 12,000 r.p.m. are available. Illustration shows a machine for balancing gyro rotors. The rotor is mounted on rigid bearing supports and the entire assembly is seismically suspended on springs to eliminate disturbing influences of floor vibrations. Electronic control cabinet is at right. Cathode-ray tube screen, which appears at eye level, is graduated horizontally into 360° for reading location of unbalance and vertically into units representing amount of unbalance. Most machines are driven by a small air turbine wheel which slides over end of rotor shaft to be balanced.—*Sonntag Scientific Corp., 1 Seneca Place, Greenwich, Conn.*

Explosion-proof Baths and Ovens

Makers announce that they have extended their line of explosion-proof laboratory equipment to include electrically-heated temperature control cabinets and constant-



temperature baths. All wiring is enclosed in vapor-tight explosion-proof conduit fittings to eliminate open arcs, in conformity with Underwriters' requirements applying to Class 1, Group D, "Hazardous Location," and all electrical controls are mounted in explosion-proof housings. Heaters are of low wattage density for minimum temperature differential between air and heater surface. Heating elements are ribbon, to allow a large expanse of heat-dissipating surface for a given wattage, and operate at black heat. Thermostat is located in a separate compartment away from working chamber, and is enclosed in an explosion-proof metal housing. Doors are equipped with a safety release latch to allow automatic openings for releasing any internal pressures which may develop, and a door switch automatically disconnects entire electrical circuit including the heaters, thermostat and control switches, when door is opened. Illustrated is a temperature control bath available for reduced or elevated temperatures in a variety of sizes and operating characteristics.—*Precision Scientific Co., 1750 N. Springfield Ave., Chicago 47, Ill.*

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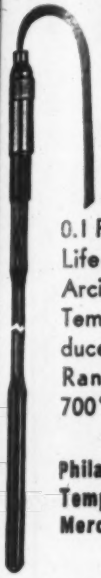

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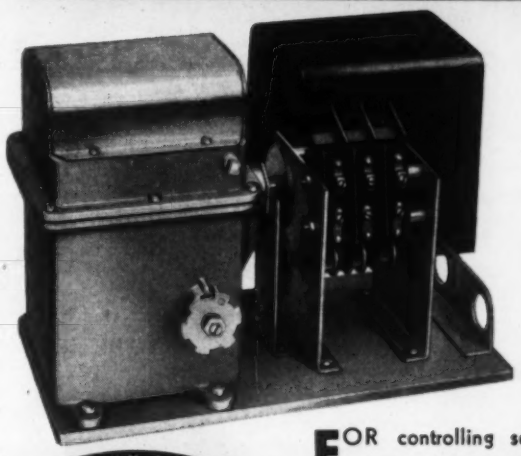

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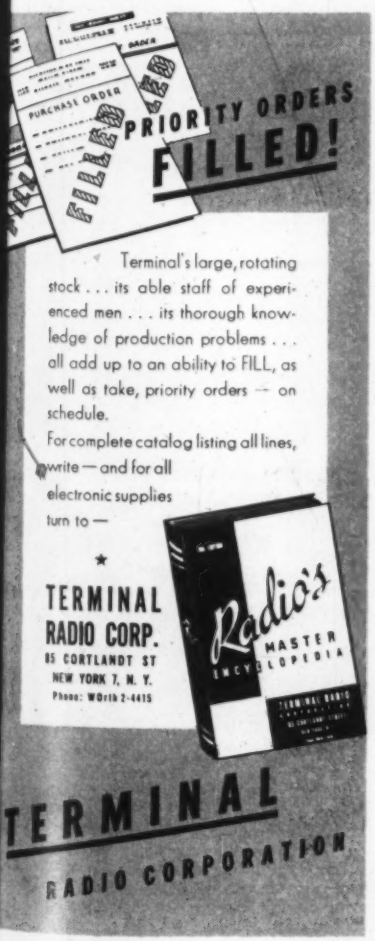
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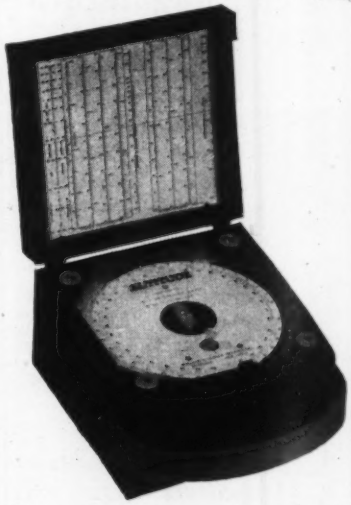

so that no special compensating elements are necessary. On altimeter, for example, deviation is less than 0.1 ft./°F. temperature change up to 7,000 ft. The instrument is thus particularly suitable for work involving instantaneous readings over wide ranges of temperature and pressure. It is said that because of absence of friction, tapping of the dial is unnecessary when taking a series of readings. Drift of pointer with time is said to be negligible. Simplicity of design helps instruments to hold accuracy under severe usage conditions. For portable service, they are available in shock-proof protective cases. They can also be furnished for wall or panel mounting. Availability is currently limited to essential applications for which a high priority can be obtained.—*Wallace & Tiernan Products, Inc., Belleville, N. J.*

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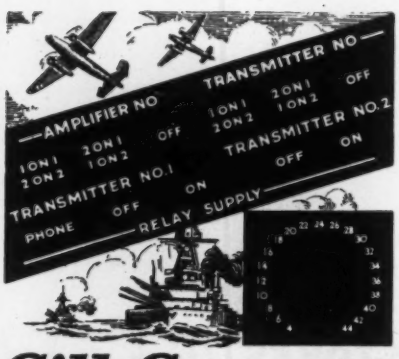

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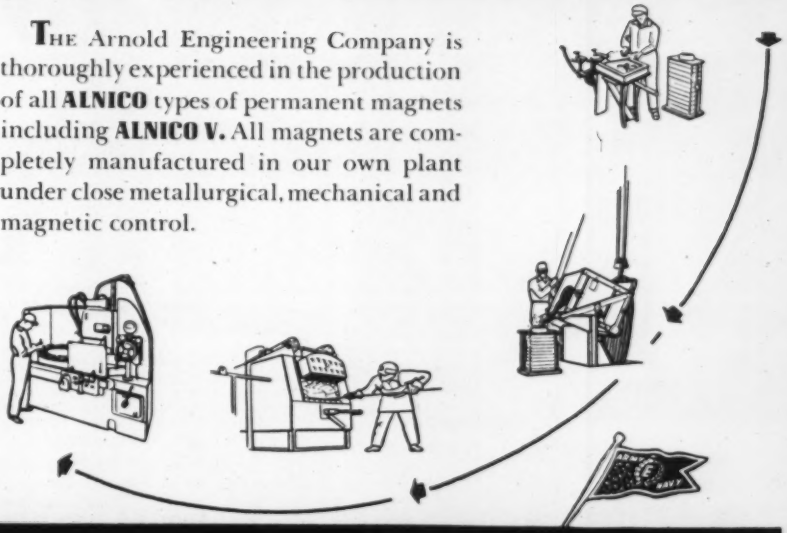

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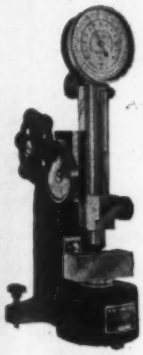

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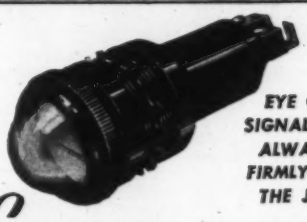

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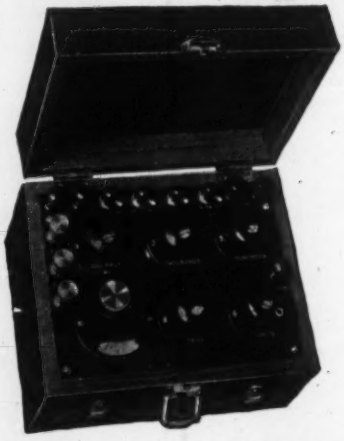

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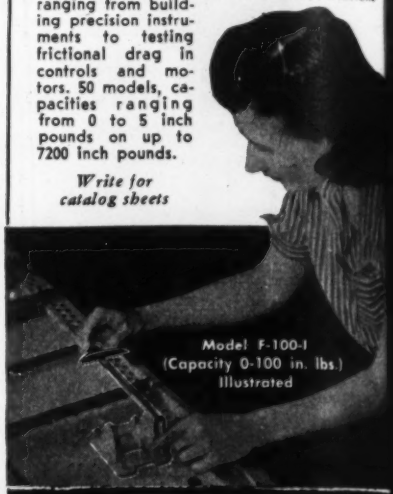

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Manufacturers' New Literature

In this department we report ALL pieces of new literature pertaining to Instrumentation received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

K-358 **Direct Recording Oscillograph.** Booklet 101, 5½" × 8", 8 pages, with a sample recording enclosed, describes frequency response and sensitivity of inkless recorder. Suggested hook-ups and dimensional outline included. Rahm Instruments, Inc., 12 West Broadway, New York 7, N. Y.

K-359 **Corrosion Test Equipment.** Folder, 8½" × 11", 2 pages, describes and illustrates salt spray equipment designed to test electroplated or coated metal parts, lacquered or painted samples, etc. Industrial Filter & Pump Mfg. Co., 1621 W. Carroll Ave., Chicago 12, Ill.

K-360 **Electronic Devices.** Folder 9143, 8½" × 11", 4 pages, illustrates many applications of electronic devices for multiple counting, combustion control, synchronizing conveyor operations, guarding against trespassers, etc. Worner Electronic Devices, 846 N. Noble St., Chicago 22, Ill.

K-361 **Automatic Line Voltage Control.** Bulletin 163, 8½" × 11", 4 pages, describes the Seco automatic voltage regulator for maintaining a constant output voltage. Superior Electric Co., Bristol, Conn.

K-362 **Relays.** Bulletin C, 8½" × 11", 4 pages, shows standard mercury plunger relays which are carried in stock. H-B Electric Co., 6122 N. 21 St., Philadelphia 38, Pa.

K-363 **Granite Surface Plates.** Folder, 3½" × 8", 6 pages gives specifications, prices and special features for 4 sizes of granite surface plates. Herman Stone Co., 1238 Leonhard St., Dayton, Ohio.

K-364 **Remote Water Level Indicator.** Bulletin WG 1820, 8½" × 11", 8 pages, covers application and operating advantages of YARWAY remote water level indicator. This is a device which brings boiler water levels down to eye level reading on a brilliantly illuminated, two-color scale mounted on the plant's instrument panel or other convenient location. Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.

K-365 **Ceramic Trimmers.** Bulletin 695, 8½" × 11", 8 pages, explains the construction principle of a stable capacitor, and catalogs four styles in current large production giving the dimensions and specifications of each. Helpful drafting drawings and actual photographs round out this desirable source of information. Centralab, Division of Globe-Union, Inc., 900 East Keefe Avenue, Milwaukee 1, Wis.

K-366 **Hydrogen Ion Recorders.** Catalog N-96(1), 8" × 10½", 16 pages, describes an equipment which consists of just two elements: an unusually rugged glass-electrode assembly and a Micromax Recorder—either a strip-chart Model S or a round-chart Model R. Through the

electrode assembly chamber flows a continuous sample of the process solution, where it completely covers the electrodes and a temperature compensator. The voltage thus set up is continuously measured by the Micromax which indicates and records directly in pH units. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

K-367 **Spark Plug Testers.** Folder, 8½" × 11", 2 pages, describes and illustrates a portable spark plug testing and service kit for the aviation industry. Airplane Mfg. & Supply Corp., 409 N. Brand Blvd., Glendale 3, Calif.

K-368 **Signaling Timer.** Bulletin A-14, 8½" × 11", 2 pages, illustrates the Series S timer designed to command visual and audible attention the instant a time interval is completed. Industrial Timer Corp., 117 Edison Place, Newark, N. J.

K-369 **Engine Room Instruments.** Catalog 5, 8½" × 11" 16 pages, has several pages on thermometers, revolution counters, etc. Other products illustrated are a ball and socket joint for remote control, steam whistles, mechanical telegraphs, ship bells, fog horns, gongs. Ballou Service & Instrument Co., Inc., 75 West St., New York, N. Y.

K-370 **Electronic Measuring Instruments.** Folder 177-3505, 8" × 10½", is a loose leaf catalogue, has a number of bulletins under the following two sections: 1. Electronic Instruments for Service Testing and 2 Electronic Instruments for Laboratory Use. Specialty Div., Electronics Dept., General Electric Co., Schenectady, N. Y.

K-371 **Calibration of Equipment in the Low and Medium Radio-Frequency in Small Steps of Frequency.** This is the title of the lead-off article in the October issue of the General Radio Experimenter. General Radio Co., 30 State St., Cambridge 39, Mass.

K-372 **Materials Inspection Magnetometer.** Bulletin 90, 8½" × 11", 8 pages, describes a model used to measure the strength and polarity of the magnetic field produced by magnetized members. Waugh Laboratories, 420 Lexington Ave., New York, N. Y.

K-373 **Instrument Washer.** Folder, 8½" × 11", 4 pages illustrates a portable electric instrument washer. Naxon Utilities Corp., 2101 Walnut St., Chicago, Ill.

K-374 **Ohmite News.** The October issue of this house organ describes the application of rheostats to a balancing machine. Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

K-375 **High Intensity Industrial X-Ray Illuminator.** Folder, 8½" × 11", 4 pages describes an illuminator for the examination of radiographs. Picker X-Ray Corp., 300 Fourth Avenue, New York, N. Y.

K-376 **Motor Valves and Power Units.** Bulletin V506, 8½" × 11", 12 pages, gives descriptions and wiring diagrams of 2-position, 5-position, and proportioning valves. Bristol Co., Waterbury, Conn.

K-377 **The C-D Capacitor.** The September issue has several interesting articles: Air-Raid Alarm Circuit; and Laboratory Hints. Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

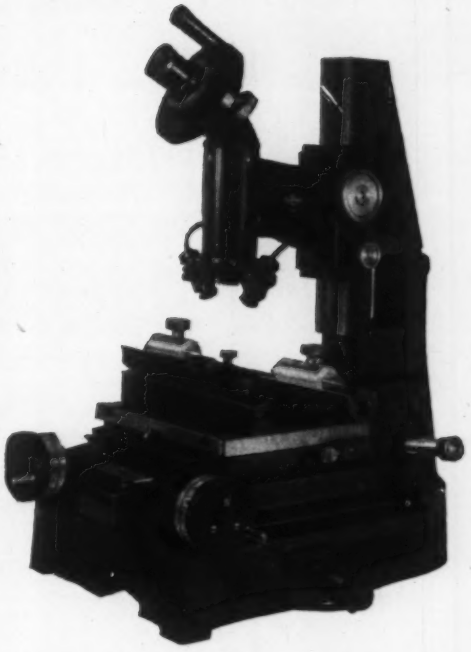
K-378 **Wire Strain Gage.** Bulletin SR-4, 8½" × 11", 24 pages has a discussion on strain determination by bonded resistance wire gages. Baldwin Southwark Div., Baldwin Locomotive Works, Nicetown, Philadelphia, Pa.

K-379 **Micrometers.** Folder, 8½" × 11", 4 pages, describes Reed Micrometers and announces a new policy of producing 1", 2" and 3" micrometers with vernier reading to tenths only. George Scherr Co., Inc., 128 Lafayette St., New York, N. Y.

K-380 **Vibration Control.** Catalog G-100, 8½" × 11", 24 pages, is a simple but comprehensive guidebook on the theory of vibration control as applied to both stationary and marine equipment. A complete guide is provided for the solution of vibration problems which arise in office buildings, industrial plants, and on board ship due to the operation of engines, grinders, hammers, punch presses, refrigerating and ventilating equipment, and other similar machinery. Korfund Co., Inc., 48-15 Thirty-second Place, Long Island City, N. Y.

K-381 **Precision-Light.** Bulletin 2031, 8½" × 11", 4 pages, illustrates a light for precision work. Diehl Mfg. Co., Finderne Plant, Somerville, N. J.

K-382 **Cenco News Chats.** The October issue has an article on J. Willard Gibbs, who carried out basic work in thermodynamics and equilibrium. A number of



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